INDUSTRIAL PLASTICS TECHNOLOGIST'S DUTIES AND TASKS TO MEET EMPLOYER NEEDS IN THE GREATER DAYTON, OHIO AREA

DISSERTATION

Presented in Partial Fulfillment of the Requirements for

the Degree Doctor of Philosophy in the Graduate

School of The Ohio State University

By

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ABSTRACT

This 2008, descriptive survey research explored and identified duties and tasks on the demand side of what industry needs in a plastics technologist. This occupational study was initiated with the endorsement of five professional organizations and covered 29 plastics manufacturers in the greater Dayton area. The occupational analysis method called DACUM (Developing A Curriculum) was used to identify the duties and tasks and related core competencies (Norton, 1997). An expert panel for the DACUM process consisted of experienced practitioners working within the plastics manufacturing field. In the two day event the DACUM expert panel identified the duties and tasks. These duties and tasks were then organized into a DACUM Research Chart containing 11 duties, 78 tasks and 72 enablers. Finally the duties, tasks, and enablers were verified by the DACUM expert panel. The DACUM research chart was used to develop a task verification survey chart for plastics technologists. The task verification survey consisted of enablers, demographics from responders, processes used in manufacturing, and the three most important research questions. The questions are as follows: 1) Does an entry level plastics technologist

PERFORM this task? 2) How **IMPORTANT** is this task in the performance of your job? and 3) How **DIFFICULT** is it to perform this task?

The population of plastics companies in the Dayton, Ohio area was determined to be 29 and one survey questionnaire per company was administered. The task verification survey was mailed to the qualifying and volunteer plastics technologists employed in the manufacturing of plastic products. The survey data collection period of 30 days yielded a response rate of 93 percent. The survey responses led to the following findings: (1) the DACUM process has resulted in information useful for plastics technology curriculum development for a two-year community college; (2) the differences in the tasks percentages and standard deviation shows small gaps for possible curriculum improvement for entry level, tasks importance, and difficulty to learn job; (3) the respondents with post secondary degrees tended to rate certain tasks and enablers higher than the responders with less education; (4) the recommendation for Sinclair Community College's plastics technology program is to address each high task percentage or mean and determine if it is being taught, analyze how the task could be integrated seamlessly into the curriculum, and balance classroom time around the needs of the plastics manufacturers.

DEDICATION

This dissertation is dedicated to those who have inspired this Ph.D. quest:
my parents, Casper and Evelyn Meyer (deceased), Kathleen (spouse),
and family, the late Dr. N. L. McCaslin, and the
many friends lost during Vietnam

ACKNOWLEDGEMENTS

This page acknowledges many individuals who helped me through my academic journey at The Ohio State University and Sinclair Community College. I am deeply grateful to all the people who have made this quest possible.

Appreciation is extended to Dr. Paul E. Post, my advisor, for his counsel and assistance both in this study and throughout the writer's total doctoral program. His guidance and support through my doctoral program has helped me grow professionally and personally.

Appreciation is extended to other members of the writer's dissertation committee, Professors Robert E. Norton and Christopher J. Zirkle. To the entire dissertation committee I am indebted to these professors for their time and effort in guiding me. A special tribute is going to Dr. N. L. McCaslin, who briefly helped me as a committee member, then recently passed away.

I gratefully wish to recognize the faculty and staff of the Technology Education Program at The Ohio State University. Dr. Karen F. Zuga encouraged me from the start by showing internet research capability and writing styles. Thanks to Eilene Reece, Peter O. Lund, Mark Mahoney, Sandra J. Reed, and Brian Snyder for their support and encouragement throughout the doctoral program. A special thank you goes to Dr. Larry E. Miller for his very effective methods in survey research.

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VITA

March 23, 1944..........Born – Cleveland, Ohio

1962............................Aircraft Systems Technology, Amarillo Air Force Base, Texas

(Served three years overseas as a crew chief on a fighter-bomber)

1969............................B.S., Industrial Technology Education, The Ohio State University

2003............................Masters in Business Administration, Jones International University

(Majoring in Entrepreneurship)

Manufacturing Work Experience

1969 - 1973.................O. M. Scott & Sons, Project Engineer

1973 - 1974.................Oury Engineering, Design Engineer

1974 - 1984 ....Joy Manufacturing/Krasco, Chief Engineer (R&D)

1984 - 1987 ....Baxter Healthcare, Plant/Operations Manager

1987 - 1997 ....Dayton Progress, Engineering Director

1997 - 1998 ....Whistler-Automation, Plant Manager

1998 - 1999 ....DAP, Plant Manager

College Teaching Experience

1996............................Adjunct Professor, University of Dayton

2000 to present...........Associate Professor in Manufacturing Engineering Technology, Sinclair Community College, Dayton, Ohio

Professional Registration/Licenses

1967 to present...........Licensed Private Pilot

1980 to present...........Licensed and Registered Professional Engineer in Ohio and Florida

Membership in Professional Societies

1980 to present ....National Society of Professional Engineers (NSPE)

2000 to present...........American Society of Engineering Educators (ASEE)

2000 to present...........Society of Manufacturing Engineers (SME)

Honors/Awards

1962............................Outstanding academic achievement award for highest GPA at Amarillo Air Force Base's Aircraft Systems Technology School

1989 and 1992............Granted two patents for Dayton Progress

2005............................NASA shuttle flight for initiated four-inch student developed/built model of the Wright Flyer

2005...........................Recipient of Dayton, Ohio's prestigious Affiliates Societies

Council (ASC), "Outstanding Scientists & Engineers Award"

2002 through 2006.....TAC/ABET training, assessment, and accreditation

PUBLICATIONS

1. D. G. Meyer and S. Harper authored and presented white papers "Capturing Flight." American Society of Engineering Educators Conference (2002).

2. D. G. Meyer and S. Harper authored and presented white papers "Model Wright Flyer." American Society of Engineering Educators Conference (2003).

FIELDS OF STUDY

Major Field: Education
Specialized Area: Technology Education
Additional Studies: Industrial Systems Engineering and Business Management

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CHAPTER 1

INTRODUCTION TO THE STUDY

Dayton, Ohio became world famous with the invention of the airplane and powered flight in 1903. Before, during, and after this era, from the mid 1800s through 1990, the Dayton area was a hot-bed for manufacturing, research and development, and entrepreneurism. More recently, traditional manufacturing has given way to high-tech manufacturing methods, equipment, materials, and the need for employees who possess new knowledge and skills. These high-tech jobs are in aerospace, automotive, medicine, and advanced manufacturing. Most of these high-tech jobs require the use of the latest advanced materials to reduce costs and weight, and sometimes with higher load carrying capability. Most traditional manufacturing materials started with fabric, wood and leather, and moved into metal materials. Today, manufacturers have advanced metals, plastics, composites, and a new field called nanotechnology. Many of today's high-tech businesses are in the field of plastics, where plastic resins are now combined with high-strength filler materials (metallic, carbon, plastic and glass fibers) to form composites (Lokensgard, 2004). The field of nanotechnology uses submicron size composite fillers, which has opened up technology opportunities for fuel cells (nanocomposites), other new materials, new medical breakthroughs, and entrepreneurism.

Today, the U.S. is competing globally in manufacturing and to be successful a skilled workforce with the right knowledge and skills is very important. To obtain the right knowledge and skills employees need to be educated in their career high-tech specialty area. Without the correct employee education business will suffer, which could affect Dayton's manufacturing capability and our economy. This research proposal is focused on the high-tech and growing industry of plastics, an important part of advanced manufacturing.

Dayton's Manufacturing History

The greater Dayton area has a rich history famous for technology, research and development (R&D), local resources, and having the hands-on technical skills to manufacture many types of consumer goods. Many innovations were developed and manufactured locally, including the Wright Brothers' airplane in 1903, Patterson's cash registers, Kettering's automotive starters in 1919, parachutes at Wright-Patterson Air Force Base (WPAFB) before WWII, the little known "Fraze" improved beverage can in 1959 (Fraze, 2007), William R. Gaiser's patented "plastic water container" (Gaiser, 1985) in 1973, and numerous other products that are used globally today. Each of these products started with a need and then grew into ideas where hands-on practitioners using hand tools, lathes, milling machines, and much research and development, created the end product. These and other new consumer goods gave Dayton a reputation as an innovative leader and manufacturer of high quality goods. Many of these innovations created great wealth for their inventors from patents and side products. Some innovators became known as entrepreneurs for taking their ideas and building their company around it and then taking the product idea to market. This was the case for all the new products mentioned.

An entrepreneur creates new products of value for others while also creating self-wealth. These successful entrepreneurs had the necessary technical skills plus the ability to design, develop, test and integrate the manufacturing technology and materials of the period. Each of these hands-on practitioners took ideas and turned them into marketable products. Thus, the skilled entrepreneurs in Dayton became the economic engine for the area.

In 1884, as product demand grew and factories expanded, the need for skilled workers was seen by the Dayton, Ohio resident, David A. Sinclair (Orenstein & Walter, 2004), the founder of Sinclair Community College (SCC). Driven by need, Mr. Sinclair started teaching the skills the manufacturing community needed. This was an era when the Dayton area was thriving economically with many different industries, and urban expansion was taking place. For companies to move forward and expand, the employers needed help. They cited a skilled worker shortage as their main concern. In this era, many young local and immigrant workers were unskilled and unemployed. Mr. Sinclair saw the workers' and the manufacturers' need, explored the possibilities, and then arranged for courses to be taught. He started with the teaching of mechanical drawing and design followed by courses in materials.

For factories to prosper and expand their business a skilled workforce was needed, so SCC continued to do what they did best. Thus, the continuing cycle of educating employees to a high skill level, all based on local industrial need, allowed business and the school to thrive. As Dayton grew in size and its reputation for progressive technology continued, its economic success also followed. Dayton's manufacturing reputation was retained and brought many talented people to the area.

Over the years Dayton became known for its skilled workforce, its precision manufacturing ability and its entrepreneurship. Over this same time period, there was a steady transition in the use of materials beginning with wood, fabric and wire used on the Wright Brothers' airplane through today's specialty metals, plastics and composites used in the manufacturing of aircraft, automobiles and other consumer goods. The first traditional materials have been slowly displaced over the years by the more recently developed and advanced high-tech materials. Companies usually went after these advanced materials to be used in consumer goods for reasons including lower initial material cost, higher strength characteristics, and lower processing cost, to name a few. This has led to a continuous stream in development of new materials. Today, the fastest growing field of materials is plastics and rubber, with new materials being introduced every month.

Along with the development of materials was the continuous improvement and precision in machine tools and specialty metals, like the tool steel used to make a mold for the plastics industry. In the 1960s and 1970s, Dayton had a world-wide dominant position in precision tooling in addition to world-class manufacturing techniques. By 1980, Dayton was known nationally as the third largest community for precision tooling and machining (Dayton Tooling and Manufacturing Association [DTMA], 2007). The ability to precision manufacture tools was important because it supported all other industries. The reputation for tooling and machining was important to major manufacturers like General Motors, Ford, and Chrysler, which had come to this part of Ohio to build their plants in the 1950s. Then in the 1970s and 1980s, Honda, Toyota, and others came. These automobile manufacturers were drawn to South West Ohio for the skilled workforce and the resources they needed, like tooling and machining, to support their manufacturing.

The need for quickly delivered tooling to a precise and accurate tolerance was what manufacturers needed in the 1990s. This is still true in today's market where products require tighter tolerances, and the need for quality requires the use of precision tooling. Dayton's continued dominance was due to a highly trained and skilled workforce with hands-on ability to produce precision tools. To produce a precise tool one starts with tool steel. Tool steel is selected for its hardness, toughness, and wear resistance. Then the steel is transformed by grinding followed by a polishing process performed on the tool's outer surface to remove material until the tool has the precise tolerance. Today's tools have precise tolerances to within ten millionths of an inch and are hardened for tool toughness and long life for the end user. Long-life tools allow a manufacturer to economically produce their products for the automotive, plastics, composites, construction and other consumer goods fields.

In the 1970s, before computerized-numerical-control (CNC) machines, good hands-on skills were required to run the machine shop equipment. Then, as new technology emerged through the years, it required a higher level of workforce skills. Where past hands-on skills performed the precision needed, the most current CNC automation technology produces the precision tooling and manufactured product with no hands-on skills. The once required hands-on skills have given way to higher levels of thinking and interpersonal skills and technology utilization. Today's market conditions require maintaining a competitive edge by using all resources including human resources. This technological change to CNC equipment has affected virtually all manufacturers in the U.S., creating a skills gap that began to appear in the Dayton, Ohio area in the 1990s (DTMA, 2007).

Within this 1990s era, and as the new global economy slowly emerged, a few major concerns helped local manufacturers decide to relocate off-shore. The trade policies of NAFTA (North American Free Trade Agreement in 1994) opened the U.S. doors to the lower cost foreign countries. Then educators in the U.S. started to study the manufacturing skills gap, which had affected the entire nation. With the trade policies and the ability of competing low-wage countries to purchase the latest CNC technology for producing consumer goods and tooling, the low-wage countries gained an advantage over the U.S. These competing countries found CNC technology efficient, precise and cost effective and with CNC machine tools they could produce their own precision tooling. Thus, the introduction of new CNC technology to the world hurt many traditional manufacturers, including those in the greater Dayton area. This was due to both the heavy concentration of traditional manufacturing and the presence of the tooling and machining industry located in the area. Dayton's once strong reputation as a tooling and machine area leader started to diminish.

Entrepreneurs in Dayton

Over the past 40 plus years, two already mentioned entrepreneurs from Dayton have changed the world with their ingenious inventiveness and skills, due to their background in tooling, machining, and materials. These world leaders in technology have impacted many people in the world. Yet the average person in Dayton, Ohio has never heard of these entrepreneurs. However, what they accomplished with their knowledge and skills has contributed to almost everyone's social pleasure. Globally they are obscured, yet they each developed a process and product that the major population in the world has seen and used.

Ernie Fraze developed the metal quick-release pull-top concept for thin metal beverage containers in the 1960s, while William Gaiser developed the plastic water beverage container process in 1973. Both gentlemen were tooling and machining practitioners who took their ideas from concept to market successfully.

Ernie Fraze's concept was to replace the old beverage can opener (Fraze, 2007). This required over 70 individual metal forming and shearing tools, located into a tool die. Great manufacturing precision was needed for customer ease in opening the metal container. This was accomplished by the controlled shearing of metal. Metal shearing is enabled by metal "scoring" (accomplished by metal shearing of two-thirds the metal thickness). When the tab was pulled up the force against the "scoring" shears the remaining one-third metal thickness, thus opening the container. The first concept was a removable throw-away tab, which became an environmental issue (see Figure 1.1). This was patented in 1967. In 1977, Fraze patented the first push-in and fold-back tab (see Figure 1.2). This tab remains attached to the container and is current technology (see both concepts next page). Mr. Fraze started Dayton Reliable Tool and Manufacturing Company (DRT), which today manufactures complete metal tab machinery systems for use around the world.

Figure 1.1: Old Style Tab

(1967 patented throw-away tab)

Figure 1.2: New Style Tab

(1977 patented push-in and fold-back tab)

Photographs by: DRT (Fraze, 2007)

Mr. Gaiser has led the world in developing the two-stage plastic bottle-making process using PETE (poly-ethylene terephthalate) plastic material. In 1973, the first prototype "preform" metal mold was developed. This new concept consists of a two-stage process. It begins with the injection molding process of a "preform" that has an open pre-threaded top (see Figure 1.3) and a closed end cylinder bottom. In the second stage, the "preform" is subjected to heat below the pre-threaded top (the closed end cylinder bottom) and the blow molding process develops the final shape prior to the liquid fill process (see Figure 1.4).

Figure 1.3: Preform

First stage - The “preform” - a closed-end cylinder with an open threaded top (injection molding process)

Figure 1.4: Final Container Shape

Second stage - The “preform's” closed end is heated and using the blow molding process is formed to final shape

Photographs by: Researcher

Years ago William Gaiser started Broadway Companies, which consists of Broadway Mold Inc., and Encon (Engineered Containers). Encon in Dayton manufactures “FDA approved preforms” today (an FDA grade of material is required for any container whose liquid content could enter the human body). They specialize in bottle sizes consisting of 20 fluid oz., one-half liter, one-liter, two-liter, and three liter bottle preforms, which are sold world-wide. Throughout the past 35 years, Mr. Gaiser has received numerous patents, awards, and tributes for his many contributions to the plastics industry.

These local entrepreneurs' technology has advanced other companies into using similar manufacturing methods. Today, some preprocessed food packaging uses the quick-release pull-top concept and most five-gallon water jugs use the preform and blow molding concept. Both of these technologies are commonplace today. This strongly suggests that entrepreneurship promotes other inquiries which lead to other inventions and then entrepreneurship.

These Dayton entrepreneurs of beverage containers have led the world with their products and have created new jobs in Dayton and elsewhere. For the era, this was advanced manufacturing and these jobs required hands-on skills and knowledge, and provided good paying jobs that have helped the local economy. However, the pace of change in technology in the 1960s and 1970s was slower due to the use of traditional manufacturing skills compared to today's faster pace of new knowledge and advanced skill requirements.

From the 1960s with metal containers, the U.S. headed towards high-tech plastics in the 1970s. Both entrepreneurs accomplished their feat in an era which required the manufacturing skills of the day. However, today's most successful manufacturing entrepreneurs need employees with current knowledge and skills about materials, equipment, and high-tech (advanced) manufacturing methods to be able to compete.

Dayton Area Curriculum Needs

At SCC, plastics are a subject taught in our Operations Technology (OPT) program. Currently, within the OPT program and under the Manufacturing/Industrial Engineering Technology (MET) option is the sole remaining course in plastics at SCC. Over the last five years enrollment in plastics courses has declined. Three years ago SCC had six courses in plastics, which were reduced down to three, one year ago, followed by another reduction of two courses in the fall of 2007. Comparable programs like our Quality Engineering Technology and MET program have also declined and have had courses removed. This downward trend in the number of courses is a result of too few students taking classes in the area of MET at SCC. The remaining plastics curriculum teaches students to be technicians or technologists in the workplace. At nearby Edison Community College the entire plastics program was eliminated five years ago due to low enrollment.

The definition of a technician is: “A worker who works in direct support of engineers utilizing theoretical knowledge of fundamental scientific, engineering, and mathematic design principles” (Technician definition, 2008). SCC students are called plastics technologists. For the students at SCC, a plastics technologist provides assistance to a Manufacturing or Industrial Engineer, to plant management or to a production manager. Plastics technologists are problem solvers who provide testing of plastic materials and processes; they interact with management and the worker on the production floor to insure efficient operations, and they interface with customers to meet their needs.

However, SCC does not know for sure if what they are teaching is meeting the needs of business. SCC has not conducted in the past 20 years or more (SCC's Professor Thomas Carlisle - personal communication, December 6, 2007) an assessment of actual industry needs based on a particular occupation. A proper occupational assessment would determine the duties, tasks, and skills that a practicing technologist needs in a particular manufacturing field.

SCC believes it has a complement of manufacturing technology courses that teaches the most current manufacturing knowledge and skills. However, SCC does not have the evidence to support this claim.

Purpose of the Study

This is a descriptive research proposal to explore and identify information on the demand side of what industry needs in a plastics technologist. These needs will be evident in the duties and tasks identified as currently needed by plastics technologists. This study will cover plastics manufacturers in the greater Dayton area consisting of nine counties. The findings could then assist SCC in determining what current MET courses and course content should be taught. Determining what the duties and tasks are, and then modifying curriculum to match the local manufacturers' needs, will assist the college to better prepare students to become skilled plastics technologists. Then, the new plastics technologists, with improved workforce skills and knowledge, could be better equipped to help their employers, plus give the technologists career abilities needed for success. Better prepared employees, in turn will assist local plastics manufacturers in becoming more competitive, possibly regaining lost markets or finding new markets.

A "skill gap" has both a demand (from the manufacturer) and supply side (from SCC). The demand side is what manufacturers are seeking and the supply side is what SCC provides. A skill gap is measured by comparing the demand side to the supply side. This proposal is exploring the demand side only. The supply side could be measured after the demand side is measured by using a Systematic Curriculum and Instructional Development (SCID) process (Norton, 2007).

The term "skill gap" is sometimes called by other terms which mean roughly the same thing. These are: "skill shortage," "talent crisis," and "education gap," to name a few (National Academy, 2006). They all translate into a shortage of skilled employees that are needed in manufacturing or business today. All of these terms are general and are not specific to a particular occupation. When a specific occupation is being considered, from an employer's viewpoint, the occupation is broken down into duties and tasks that need to be performed in that occupation. To perform these duties and tasks requires certain knowledge and skills. The skill gap is the difference between what educational institutions are teaching and what skills businesses need in an occupation.

The rapid speed of our technology over the past 15 years is out-pacing the average person's ability to absorb the knowledge and learn the skills that business needs today (Hayes, Pisano, Upton, & Wheelwright, 2005). This creates a gap between what an employer is seeking in an employee and what that person brings to the interview. The employer is asking the question, "What can you do for me?" The translated response is, "Not too much!" Thus, a gap of many proportions is left.

The local skills gap for plastics technologists has been acknowledged by many professional organizations. Letters of support for an occupational analysis study were provided (see Appendices A through E). Each organization expressed a need to study plastics technologists.

The purpose of this study is to identify employer skill needs for entry level plastics technologist as an occupation. More specifically, this study will focus on: the duties; tasks; knowledge and skills; worker behavior; tools, equipment, supplies, and materials; and future manufacturing trends of a plastics technologist. The entry level plastics technologists being considered in this study are college graduates with a two-year Associates Degree in Manufacturing or Industrial Engineering Technology, with plastics knowledge and co-op experience. The outcome of this study will determine what are the prioritized entry level plastics technologist's duties and tasks.

Statement of the Problem

The problem addressed by this study is to identify what a plastics technologist needs to know and be able to do in manufacturing today. This study was conducted to determine a plastics technologist's duties and tasks. More specifically, SCC needs to determine in the greater Dayton area what are the duties and tasks of entry level plastics technologists, who today are faced with new and rapidly changing equipment and operational processes. This rapid change has created skill gaps. In the past, the pace of change for plastics technologists and most other occupations was slower compared to today's fast-paced computerized age. This means students need to perform different skills due to the advances in technology today. Along with the faster pace, plastics technologists have a greater number of duties and tasks assigned to their job, than in the past. This need for higher levels of competence has been verified through studies in the workplace that found a skill gap exists.

At a recent SCC conference, Dr. Holbrook (then President of The Ohio State University) indicated that there is a national employee skills gap that manufacturers need to overcome to be competitive in the world (Earls & Holbrook, 2007; Society of Manufacturing Engineers [SME], 1998; SME, 1999). The Dayton, Ohio area feels an even greater severity of this skills gap due to its smaller population size and heavy concentration of low skill rust-belt manufacturing, which is currently moving outside the U.S. and is being downsized locally. Where "rust-belt" traditional manufacturing and plastics manufacturing declined in employment in the greater Dayton area, the decline in employment in the plastics area was less severe. As traditional and plastics manufacturing downsized to become more competitive some of the downsized technical personnel became entrepreneurs and started their own facilities. Thus, both traditional manufacturing and plastics companies increased in number with plastics increasing at a higher rate.

With global competition driving local manufacturing off shore the need to expand into the high-tech area of plastics and composites exists. "Rust-belt" traditional manufacturing is leaving the Dayton area due to the low skill levels required and low monies being paid elsewhere. This leaves the growing high-tech field of plastics and composites with higher wages being paid. The greater Dayton area needs to focus on industries with the most potential to lead to higher employment and economic growth in the future. With local research facilities like the National Composite Center and Wright-Patterson Air Force Base (WPAFB) developing new materials and processes, it is natural that a local facility will be manufacturing the plastics or composite products needed.

To help close this skills gap of a plastics technologist from an employer's perspective it is imperative that SCC determine what are the duties and tasks of this occupation. This study determined the general knowledge and skills required, worker behaviors and tools used in this occupation. Thus an occupational study with a focus on the plastic technologist was conducted to determine what the technologist needs to know.

This research study used a DACUM (Developing a Curriculum) process to accomplish an occupational analysis of the plastics technician's duties; tasks; general knowledge and skills; worker behavior; tools, equipment, supplies, and materials; and future trends and concerns in the greater Dayton area. The DACUM process is a proven and cost effective method for quickly determining the competencies that are performed by individuals employed in a specific occupation.

Significance of Study

This study will be helpful in determining the demand side of skill gaps consisting of the duties and tasks of plastics technologists. The study targets new hires and other employees who already have experience working in that capacity. These groups of plastics technologists are also known as practitioners in the field. For SCC students, practitioners are those individuals practicing in a field who have some form of plastics education, hands-on experience, knowledge, and skills to perform their jobs. This research study is focused on the plastics technologist's skill gaps within the duties and tasks, from a practitioner's viewpoint. This information on skill gaps could then lead to curriculum improvements which could benefit students, employers, SCC, and the local community.

Throughout the years, many organizations have studied the duties, tasks, and skills in many manufacturing fields, but with few studies in the plastics area. The studies found are too broad, are outdated, are not specific to the plastics industry, or the focus is on locations outside of the Dayton area.

Research Questions

The proposed descriptive research study identified the skill needs for plastics technologists in the greater Dayton, Ohio area. The questions considered the whole occupation of a plastics technologist from entry level through an advanced level. The purpose of this investigation is to answer the following research questions:

1. What are the **duties** and **tasks** that manufacturing employers need for a manufacturing plastics technologist to perform?
2. What are the entry level tasks as indicated by a consensus of manufacturing plastics technologists?
3. How do manufacturing plastics technologists rate each task on:
    a. Importance to the job?
    b. Difficulty to perform?

Objectives of the Study

The goal of this proposal is to determine the duties and tasks of a plastics technologist in the greater Dayton area. To meet this goal, principal objectives are formulated and then subdivided into tasks. The objectives are:

Phase I – DACUM Workshop

This phase took place at SCC in January 2008 and needed prior approval from SCC's Institutional Review Board (IRB).

- **Objective 1 – Determine duties and tasks of plastics technologists using a DACUM (Developing a Curriculum) study.**

Phase II – Development of the Task Verification Survey Instrument

This phase took place in March and April 2008 and needed approval from The Ohio State University and SCC's IRB before proceeding.

- **Objective 1 – Develop a duties and tasks verification survey instrument.**

Phase III - Implementation of Task Verification Survey Instrument

This phase took place in May and June 2008.

- **Objective 1 – Administer task verification survey instrument.**
- **Objective 2 – Receive a high response rate from task verification survey instrument.**
- **Objective 3 – Analysis the data and report the findings.**

Research Design

The proposed descriptive survey research determined what duties and tasks plastics manufacturing companies need from their plastics technologist employees. This is very important and significant research which could lay the foundation for

Manufacturing Engineering/Manufacturing Technology curriculum change at SCC. This change could better prepare students with competencies that industry had a role in developing to be successful as plastics technologists. For this research, three occupational analysis methods were evaluated including: personal interviews, the Delphi method and the DACUM process. This study used the DACUM process due to its speed, high reliability and validity capability, and being less costly to implement. In addition, the DACUM result provides data for developing a survey instrument to collect data on task importance to the job and task difficulty to perform.

This occupational analysis was conducted using the DACUM process by using a panel of eight volunteer expert plastics practitioners. For the DACUM, an expert is a person who has experience in the occupation being evaluated. The criteria for this research panel of experts included having a plastics technologist's education level higher than high school and having five or more years of hands-on industrial experience as a plastics technologist. However, upper management personnel (i.e. plant manager, V.P., or CEO) do not qualify to serve on this expert panel. The expert panel members were recommended by three professional organizations: the American Society for Quality (ASQ), the Society of Manufacturing Engineers (SME) and the Dayton Tooling and Manufacturing Association (DTMA). The three organizations provided a list of 23 names and each person was contacted in the order the name was received. Each person was explained the importance of this study and was asked to volunteer for the two day workshop. This convenience sample method secured the panel members and the

DACUM recorder. A certified DACUM facilitator conducted the DACUM workshop with a DACUM recorder. First the chosen experts went through a DACUM orientation, and then, by use of brainstorming, discussion, and consensus seeking techniques, they identified the duties and tasks for the plastics technologist occupation, in two days. In addition to the technologist's duties and tasks the DACUM process also obtains expert consensus on: general knowledge and skills; worker behaviors, tools, equipment, supplies, and materials; and future trends and concerns.

Limitations

- Limitations – Only nine counties within the greater Dayton, Ohio area were considered for this research study. Thus, the study may not be generalizable to other geographic regions.
- The survey was sent to individuals employed by manufacturers with 50 or more employees in the greater Dayton, Ohio area.
- The survey was to only the company management selected plastics technologists (only one and possibly more in each of 29 companies), but limited to plastics technologists with five years of plastics manufacturing processes experience.
- The survey was sent to only one plastics technologists at each company.

Assumptions

- The subjects selected for this survey study were representative of practicing plastics technologists.

- The survey went to the different genders in a ratio which represents the local plastic manufacturer's workforce population.
- The DACUM method is appropriate for correctly identifying duties and tasks of practicing plastics technologists.
- A survey of practicing plastics technologists is an appropriate method for determining if the tasks are performed at the entry level, the level of importance of the tasks, and the level of difficulty of performing the tasks.

Definition of Terms

ASQ – An acronym for "American Society for Quality."

Competency – Descriptions of the abilities one possesses when he/she is able to perform a given occupational task effectively and efficiently (Norton, 1997).

Curriculum – A description or statements about "what is to be learned" by students in an instructional program and relates to "intended learning outcomes" that have been selected.

DACUM – An acronym for "Developing A Curriculum." An innovative approach to job, occupational process, and functional analysis that involves bringing a committee of expert workers together under the leadership of a trained facilitator. Modified brainstorming and consensus seeking techniques are used to specify in detail the duties and tasks; general knowledge and skills; important worker behaviors; tools and equipment; and future trends and concerns that successful workers, in their occupation, must perform (Norton, 1997).

Delphi Method – An approach to job and occupational analysis consisting of several rounds of questions presented to a panel of experts who are experienced in a subject area that matches the area of interest. This yields comprehensive information and facilitates consensus among the experts.

Duty – A cluster of related tasks from a broad work area or general area of responsibility (a general area of competence). Duties are identified in the DACUM process.

DTMA – An acronym for "Dayton Tooling & Manufacturing Association."

Enabling skill – A skill that helps students progress towards achievement of a performance objective.

Edison organization – Ohio has seven Edison Technology Centers which support product and process innovation and commercialization to establish and start-up technology –based business to facilitate economic growth.

Elastomer – A natural or synthetic polymeric material that has original length stretching ability of 200 percent or more.

FDA – An acronym for "Food and Drug Administration."

FTE – An acronym for "full time equivalent" for student which is 15 credit hours per quarter for three quarters.

Interview survey – An oral, face-to-face question-and-answer session between the researcher and a respondent for the purpose of obtaining information.

Job – An identified position requiring the performance of specific duties and tasks. Usually, the same tasks are performed by all workers having the same title.

MET – An acronym for “Manufacturing Engineering/Manufacturing Technology” – A hands-on practice oriented, two or four-year program where students can obtain an Associates of Applied Science degree.

Nanotechnology – Micro-sized particles of polymers (plastics) and composites (carbon, plastics) unite for very small applications like those used in the medical field.

NSF – An acronym for “National Science Foundation.”

Occupation – A work area consisting of two or more related jobs or levels (the occupation levels of a plastics technologists are entry level apprentice, followed by a mid-level journeyman, and the highest level of advanced technologists/engineer).

Occupational analysis – A process to identify the important duties and tasks for workers in any given occupation.

Plastics – A noun; an organic substance usually synthetic or semi-synthetic, that can be formed into various shapes by heating and applying pressure and being able to retain those shapes after heat and pressure have been removed.

Plastics Technologists/Plastics Technicians – Technical personnel involved in the design or production of injection molded parts or other plastic processes (blow molding, extrusion, fiberglass reinforced plastic, reaction injection molding, resin transfer molding, rotational molding, thermoforming, composites, etc.) including job titles as molding technician, quality control technician, estimator, set-up technician, etc.

Polymer – A high molecular weight organic compound, natural or synthetic, whose structure can be represented by a repeatedly small unit, the mer. Sometimes referred to as plastic (cellulose, rubber, polyethylene, or poly-ethylene terephthalate) material.

PolymerOhio – An Ohio Edison Technology Center that educates, promotes, and is a technical resource for the plastics industry in Ohio.

SIC – An acronym for "Standard Industrial Classification" – A government numbering system that classifies occupations in different service and manufacturing industries.

SCC – An acronym for "Sinclair Community College," who has 24,000 students and nine accredited engineering technology programs.

Skill – The ability to perform occupational tasks with a degree of proficiency within a given occupation. Skill is conceived of as a composite of the three completely interdependent components: cognitive, affective, and psychomotor behavior. Skills tend to support task performance (Norton, 1997).

Skills gap – The difference between the skills a person possesses and the skills required to do their work tasks efficiently (SME, 1997). The difference between the needs of the demand side of manufacturing and what the supply sides of educational institutions are teaching.

SPE – An acronym for “Society of Plastics Engineers.”

SME – An acronym for “Society of Manufacturing Engineers.”

STEM – An acronym for “Science, Technology, Engineering, and Mathematics.”

Task – A work activity that is discrete, observable, performed within a limited time period, and leads to a product, service or decision. Tasks are often referred to as the competencies that workers or trainees must obtain in order to be successful. Tasks are worker activities identified in the DACUM process (Norton, 1997).

Task statement – A description of a meaningful unit work that contains an action verb, an objective that receives the action, and usually one or more qualifiers, and represents a typical job assignment that an employer or customer would pay for (Norton, 1997).

Thermoplastic – A type plastic material that becomes soft and formable when heated.

Thermoset – A type plastic material that does not become soft and formable when heated, but cures into a non-melting, insoluble solid.

Verification – A process of having experts review and confirm or refute the task (competency) statements identified through occupational analysis on factors such as importance of the task and difficulty of task performance.

Summary

The continuous changes in the global economy and technology have made technology education a very broad topic today. In the last twenty years the U.S. has moved from a “rust-belt” to a “high-tech” technology in tools, equipment, and materials. Years ago the technology moved at a slower rate in comparison to the more rapid rate we have today. Today’s technology requires higher skills levels and higher education levels than those that were required years ago.

Technology education usually starts with the teaching of knowledge and hands-on skills to students at the grade school level and continuing on through high school. After high school those students interested in engineering or technology will pursue two and/or four-year colleges for individual courses and/or for complete degrees. Some will consider obtaining a Bachelor of Science Degree, Master’s or Ph.D. as they continue their life-long education. The technology education level this study targeted was the two-year curriculum for an Associates Degree in Manufacturing Engineering Technology at SCC, where the course in plastics is taught. The manufacturing curriculum contains traditional courses and course content, where the content tends to keep current over time. However, major recent changes in the workplace with new technology, changes in the Dayton economy, and global competition, make it necessary to reevaluate the topics taught, realign course offerings, and help educate local plastics technologists.

This descriptive research study addressed the skills gap (duties and tasks) needs of manufacturing companies who produce plastic products in the greater Dayton area. More specifically, this study is focused on employees who function as plastics technologists in a manufacturing company specializing in plastic products. No evidence of a research study was found indicating the duties and tasks of plastics technologists in the Dayton area. Chapter 2 reviews the literature related to this study.

CHAPTER 2

REVIEW OF THE LITERATURE

Introduction

The purpose of this study is to determine the plastics technologist's duties and tasks in companies which manufacture plastic product, within the greater Dayton, Ohio area. More specifically, the target skills gap is the duties and tasks that plastic technicians or technologists perform in their work routine, commonly called the demand side in education. A plastics technician is commonly called a technologist and the term technologist will be used throughout this proposal. Chapter 1 identified underlying economic problems in the Dayton area caused mostly by global competition and the disappearance of traditional manufacturing jobs. This review of literature begins with a history of plastics followed by defining what a skills gap is and by tracing the chronological development of the skills gap in the greater Dayton area. Finally, the general term, "skills gap," will focus on the specific "duties and tasks" of plastics technologists.

The Internet searches, library resources, and database findings led to dissertations, scholarly journal articles, magazines, government data studies, newspapers, books and videos in this review of literature. With these resources, the researcher found some studies on skill gaps but only a few research studies on specific duties and tasks of a plastics technologist.

History of Plastics

Plastics are the name of a family of mostly synthetic materials that are soft and moldable during manufacturing and eventually solidify. Plastics are polymers with a long carbon based chemical chain made up of repeating molecular elements. Polymers are synthetic, or natural organic compounds that form plastics or elastomers after additives are introduced into the process. Plastics are pliable and formable into a solid, whereas elastomers have great stretch ability and are commonly called, “rubber.” Resins (a polymer) are gum-like semisolids obtained from plants and trees and are additives used in the manufacturing of plastics and other elastomers.

Plastic material has its origin in the following chemical elements: carbon, oxygen, hydrogen, nitrogen, and chlorine. These materials are extracted from the air, water, natural gas, oil, coal, and even plants. The rubber and plastic industry is closely linked together due to the similar raw materials they use and closely related manufacturing processes (Lokensgard, 2004; Plastics History, 2006).

Charles Goodyear in 1839 was one of the first Americans to develop a rubber polymer process called “vulcanization.” Goodyear’s vulcanized rubber was stronger, more elastic, and more resistant to abrasion and chemicals than natural rubber. The first man-made plastic material was developed by Alexander Parkes and the organic material was derived from cellulose. When the cellulose was heated and molded, it would retain its shape when cooled. Parkes demonstrated this at the 1862 International Exhibition in London. In 1870, a synthetic plastic material was developed by John W. Hyatt, who in 1870 received a patent for celluloid. Billiard balls and combs were the first products made from the patented celluloid and they had various degrees of success. In 1870, Dr. B.F. Goodrich moved his rubber company to Akron, Ohio and a few years later he was joined by Goodyear and Firestone. The rubber and plastic industry located in Ohio because raw materials (coal and natural gas) were available in the area (Lokensgard, 2004).

Starting in the 1930s, the field of plastics development accelerated and led into many of today’s well known trade names. Some common plastics include: plexiglas, lucite, polyethylene (PE), polypropylene (PP), epoxy, poly-ethylene terephthalate (PETE – from Chapter 1), teflon (PTFE), formica, nylon, lexan, and kevlar, to name a few. Consumers have benefited from these plastics materials due to the following plastic material characteristics and products: bullet-proof vests and glass, aircraft canopies, parachutes, women stockings, plumbing and automotive products, plastic bottles, carpeting, sport boats, aircraft fuselages, scratch-proof and low friction coating, non-stick, and home insulation. The two most important characteristics of plastics are the low material costs and high strength.

"In the 1950s there were perhaps four polymers – today there are over 21,000 combinations of molecules that have imbued plastics" (Liston, 1995, p.1). The polymer field has expanded into new fields with additives (fillers) of fibers and flakes called composites. Epoxies, a class of thermoset plastics, are cured when a hardening agent is added to a filler, forming a composite structure. These fibers and flakes could be hard plastics, metallic particles, carbon, paper, talc, clay, flour, or glass (epoxy with glass yields fiberglass). When micro-sized additives are combined with resin and polymer material they are referred to as nanocomposites. Some nanocomposite additives measure one-nanometer or one-millionth of a millimeter in thickness. The development of nanocomposites has contributed to the discovery of a new field called, nanodispersion. Nanodispersion is the process of evenly distributing the micro-sized additives within a nanocomposite. Another new development in plastics is circuits made of conductive polymers. The circuit is printed on the plastic substrate to reduce costs and opens the door to throwaway electronics. The throwaway plastic material could be recycled.

Recycling of plastics in the U.S. started in the 1970s and has continued to increase in popularity where today more than 80% of the population has access to recycling services. The disadvantages are that recycling is difficult to automate, the material cost is low, and the labor-intensive recycling process is unprofitable. Recently, many automobile and other products are being designed to make recycling of plastic parts easier. However, the percentage of recycled plastics in the U.S. remains unchanged at around 5%. For most recycled plastics, manufacturers can use 10% recycled plastic material mixed with new material for a cost savings on their raw material. The recycling of plastics compares with the recycling of metal. Starting with a high grade of plastic (FDA approved PETE), the material can be recycled into a lesser grade product (automobile bumpers), and this product can be recycled again into another lesser grade product (plastic lumber). Thus, recycling reduces material costs for manufacturers and it helps the environment by not disposing usable raw material (Lokensgard, 2004).

The use of plastics conserves energy compare to using traditional metals. It takes ten times the energy to produce aluminum compared to plastics, four times more to produce copper, and three times the energy for steel (Society of the Plastics Industry of Canada, 1990). Besides saving energy plastics are generally twice as strong as steel on the pound per pound basis.

The consistant growth over the last 150 years in the polymer industry has created many opportunities. Each new experiment in the plastics field that led to newly discovered polymer products or processes has opened the door for entrepreneurs. New potential markets plus innovation leads to other new discoveries. New discoveries lead to production increases. In the year 2000, production of plastics in the U.S. reached 45 million metric tons and had been growing at an annual rate of 4.7 % from 1973 to 2000 (Lokensgard, 2004). “The United States plastics industry is a multi-billion dollar business, and it is still growing at a rate faster than most other industries in this country. Plastics have been used in every major market in the United States, including construction, packaging, automobiles and boats, electrical/electronics, pipes and fittings, and consumer goods, to mention just a few" (Polymer Plastics Corporation, 2000).

Plastics are basic materials, on par with metals, glass, wood, and paper, and they are essential to the needs of virtually the entire spectrum of American business. As lifestyles change, plastics should continue to be more valuable to tomorrow's advanced new concepts in architecture, aerospace, communications, transportation, medicine, and the arts. It is difficult to imagine what life would be like without the polymer industry today.

Technician/Technologist Defined

A technician or technologist (both terms mean the same) is a person who has duties and tasks that lie between a manufacturing engineer and a machine operator and is often called an engineering technologist. The technologist supports the engineer in accomplishing those tasks connected to company projects and manufacturing processes, and contributes to company cost savings. There is a difference between a manufacturing engineer and manufacturing engineering technologists. The engineer has a more comprehensive math and science background. While the engineer is better suited for research, the machine operator has only the skills for running a narrow range of equipment or machines. The engineer is ideally suited for research, compared to the Engineering Technology Associate of Applied Science (A.A.S.) graduate who has completed more hands-on courses combined with experience in teaming, communication skills, and problem-solving.

The engineering technology and engineering graduates have, for years, been in disagreement over who is more important in the workplace. The fact is many students who graduate with a B.S. degree in manufacturing engineering technology are assigned the same duties and tasks as an engineer with a B.S. degree and they are paid the same wage. However, those who graduate with an associate's degree in manufacturing engineering technology usually are paid less than those with the B.S. degree in manufacturing engineering technology. The engineering technology and engineering graduates each have a role to perform based on their knowledge and skills.

The plastics technologists researched in this proposal are employees who serve in the capacity of plastics technologists, or technicians with at least five years experience. Once the needed skills for plastics technologists are identified, then educational courses or course content at the college level will be modified to educate students with the skills of plastics technologists that manufacturers are seeking.

Employment Opportunities in Plastics Field

There are good opportunities for employment as plastics technologists in the greater Dayton area of Ohio. According to Deloitte Development (2005), the greater

Dayton area of Ohio is known as the southwest and west central area and jobs are available for the skilled plastics technologists. This high technology area of plastics combined with the resins, composites and nanotechnology adds even more opportunities for employment (Deloitte Development, 2005; Technology Partnership Practice [TPP], 2004). As traditional “rust-belt” manufacturers move into the advanced technology field of materials they embrace an ever-growing need to find highly skilled employees. The advanced materials field of plastics is one of these fields which needs skilled employees.

In the Table 2.1, Traditional Mfg. (rust-belt) compared to Plastics Mfg. (high-tech), the Dayton area employment for traditional manufacturing declined 26.2% while employment in plastics manufacturing declined 10.9% in this nine year span (Harris, 1999; Harris, 2008). The Dayton area number of traditional manufacturing facilities increased 5.5% while the number of plastic manufacturing facilities increased 11.9%. For this study the plastics manufacturers came from SIC (Standard Industrial Classification) 30 and traditional manufacturers came from SICs 34, 35, 36 & 37. The Cleveland area consisted of 14 counties while the Toledo area consisted of six. The Cleveland counties are: Ashtabula, Cuyahoga, Geauga, Holmes, Lake, Lorain, Medina, Mahoning, Portage, Summit, Stark, Trumbull, Tuscarawas, and Wayne. The Toledo area counties include: Fulton, Hancock, Lucas, Sandusky, Williams, and Wood. The greater Dayton area consists of nine counties including: Butler, Clark, Clinton, Darke, Greene, Miami, Montgomery, Preble, and Warren, which is the population for this study (see Appendix F).

While the poor economy, plant shutdowns, and manufacturing outsourcing have affected the Dayton area, the field of plastics continues to thrive. Both traditional and plastics manufacturing declined in employment, with plastics declining the least. The reason plastics declined in employment was due to the economy and company efficiency gains in becoming leaner with personnel. This happens during economic downturns. In comparison, the traditional manufacturers downsized personnel due to outsourcing and permanent loss of jobs. Both traditional and plastics manufacturing facilities grew in number within this nine year period with plastics achieving 6.4 % higher growth rate than traditional manufacturers. Table 2.1 indicates that plastics are doing better than traditional manufacturing in the Dayton area.

The Dayton Area Economy

Today the global economy has impacted the entire nation, but the greater Dayton area economic decline is more severe than in other areas of the U.S. The reason is that Dayton's industries are heavily concentrated in automotive, machine build, aerospace, machining components, fabrication, plastics, and tooling and machining. The largest Dayton industry is automotive, which has suffered the most. Each automotive worker supports 4.7 other workers in other industries (DTMA, 2007), so for every automotive worker who loses his job, 4.7 others also suffer job loss. These are all high paying industries requiring good skills. In the early 1990s these manufacturing jobs started leaving the area with product being produced more competitively elsewhere. This shift started with U.S. manufacturers going to Mexico for the cheap labor. More recently manufacturers have headed to China, where the labor cost is even less. When manufacturers leave an area by closing their doors, jobs are lost, workers are displaced, and the loss of the money once earned changes the local economy. The once strong manufacturing ability that Dayton was noted for is slipping away. The losses of the high paying jobs have affected payment of taxes, purchases of wanted goods and services, and retention of a strong working population in the area. Even the school systems are struggling with major tax levies being denied. The global economy and the new technology requiring higher skill levels have created the following concerns for Dayton's manufacturers and the economy:

- A nine year 26.2% loss of jobs in low skill "rust-belt" manufacturing companies in the greater Dayton area (Harris, 1999; Harris, 2008).
- The Dayton Tooling Manufacturing Association (DTMA, 2007) has seen its membership of 600 tooling manufacturing facilities in the greater Dayton area decline to 385 in six years.
- High job loss (from 2000 - 2003 over 22,000 jobs were lost in Montgomery County) (Dayton Daily News [DDN], 2006a).
- Ohio ranks third in job loss (DDN, 2007c).

- High unemployment rate of 6.9 % in Dayton compared to Ohio’s 6.7% and the nations 5.7% (Bureau of Labor Statistics, 2008; Dayton Chamber of Commerce, 2008).
- High mortgage foreclosure rates (an increase of 25% in one year) (DDN, 2007b).
- Many Dayton area school levies being denied (DDN, 2007a).
- A growing skills gap, which is affecting the entire nation (Evanciew & Wither, 2004).
- A disturbing six-year trend at SCC, with a stagnant enrollment (FTE) in Manufacturing/Industrial Engineering Technology (MET) (Sinclair Archives, 2006).
- Delphi Corporation is closing 4 of 5 existing plants in Dayton by 2008, which will displace 8,500 employees (DDN, 2006b; DTMA, 2007).
- General Motors is closing its Dayton SUV automotive plant in 2010, which will displace 2,500 employees and effect 103 Ohio suppliers (DDN, 2008).
- Dayton is named as one of four Ohio cities from a list of ten in the U.S. as, “Americas Fastest-Dying Cities” (Zumbrun, 2008).

With all the concerns mentioned, an improvement in worker skills which match the needs of local manufacturers would help the employers, the workers, and SCC. One bright spot in the greater Dayton area in manufacturing is the field of plastics, which has not been greatly affected.

Dayton’s economy is shifting from a manufacturing concentration to a service industry and any sustained economic turnaround requires a focus on manufacturing growth areas. One such growth area is the plastics field. With most manufacturing jobs paying higher wages than the service jobs, it makes sense to improve the skill sets in the higher wage businesses. The higher wages translates into higher tax dollars and more income to purchase local goods and services. Improving these skills starts with an analysis of manufacturing needs with a sharp focus on an individual occupation. The DACUM process provides that needed occupation focus, which helps in creating the survey instrument. The analysis of the survey data received assists in determining what competencies should be incorporated into classroom study. Mastery of these competencies would make the students more employable, would help current employees improve their knowledge, skills and behavior, and would improve the student’s and current employee’s potential for career advancement.

There has been very little research at SCC on curriculum needs that match the needs of local manufacturers. SCC does use industrial advisory boards, but the quality of information has been somewhat lacking over the years. This is primarily due to the heavy concentration of CEOs, VPs, and plant managers, and not practitioners, who are on the MET board. Most advisors are not daily practitioners in manufacturing engineering technology and only one comes from the plastics field. This year their was no MET industrial advisory board meeting. The researcher feels these advisors, whose primary jobs are in upper management are too distant from the practitioner working on the manufacturing floor as plastics technologists to determine the technologist's duties and tasks. However, by focusing on surveying the occupation practitioners and not upper management, this research study will provide insight for change in the plastics technology courses at SCC using the DACUM process.

Change, new technology, and new markets are the important words in this proposal, which could drive improved education and training needs for the plastics technologist. With strained local economic conditions, global competition, a national skill gap, and an aging workforce of baby boomers, the educators of today need to prepare the students well for tomorrow's enterprise. The education system needs to work with manufacturers and manufacturers need to work with the schools to produce the students with the applicable skills needed in an ever-changing environment. This proposed study will help current plastics manufacturers identify the employee skills they need and the study results will provide a basis for SCC curriculum development. The new curriculum content will strive to support the needs of the manufacturers by teaching students the needed skills.

Other possible benefits include helping local plastics manufacturing employers become more competitive, providing students with up-to-date course curriculum in plastics, helping to improve the local Dayton economy, and helping SCC with possibly higher enrollment. The questions then becomes, "Is SCC teaching the correct courses and course content on the demand side of skill gaps for the manufacturer's plastics technologists? What currently is the demand side of skill gaps consisting of the duties and tasks? This proposed research study seeks to answer these questions.

A nine year study looked at how employment and facilities have changed in the plastics (high-tech) and traditional (rust-belt) industries in Ohio (Harris, 1999; Harris, 2008). The greater Dayton area is one of three major plastic producing areas in Ohio. In this state-wide study the plastics industry is compared to the traditional rust-belt companies in the greater Dayton, Cleveland, and Toledo areas.

Ohio Employment and Facilities Gain/(Loss) from 1999 to 2008

	Traditional Mfg.	**Plastics Mfg**.
Greater Dayton Area Employment	(26.2%)	(10.9%)
Greater Dayton Area Facilities	5.5%	11.9%
Cleveland Area Employment	(19.5%)	(17.7%)
Cleveland Area Facilities	(5.1%)	7.5%
Toledo Area Employment	(22.1%)	16.5%
Toledo Area Facilities	(10.1%)	11.1%
State-wide Area Employment	(23.9%)	(17.1%)
State-wide Area Facilities	(2.7%)	6.6%

Table 2.1: Traditional Mfg. (rust-belt) compared to Plastics Mfg. (high-tech)

Ohio is in the heartland of the U.S. “rust-belt” for manufacturing. The employment changes that have occurred in Ohio have also occurred in neighboring “rust-belt” states.

In Table 2.1, the Dayton area employment for plastics manufacturing is doing better than the traditional manufacturing. However, the Dayton area had the highest percentage of employment loss in traditional manufacturing in the state. In contrast, Dayton’s employment loss in the manufacturing of plastics was less. However, the gain in the number of manufacturing facilities could suggest that those who lost jobs became entrepreneurs. The findings in a study by PolymerOhio in the Cleveland area indicate that job loss forced many talented and skilled workers into becoming entrepreneurs in the plastics field (Richard Markham at PolymerOhio - personal communication, December 20, 2007). This PolymerOhio study also concluded that the downsizing in both the traditional and plastics manufacturing sector made for more efficient operations within those facilities. One can conclude from the above chart that the plastics industry in the greater Dayton area did have a less severe downturn in the nine years of outsourcing jobs to other countries. Also the 11.9% increase in plastic manufacturing facilities in the Dayton area shows industry growth.

Demand for skilled plastics technologists continues to be consistent with the national plastic industry growth rate of 3 to 4% annually over the last 50 years (Bureau of Economic Analysis, 2006). As new facilities emerge the shortage of skilled plastics technologists becomes more apparent. A skilled plastics technologist has skills and knowledge that will support efficient business operation. These technologists can support their employer very well because they thoroughly understand and practice their duties and tasks at a high level. This annual growth rate in the plastics industry leads all other industries in Ohio in GDP (Gross Domestic Product) even with a loss of jobs.

Research indicates that the plastics industry in the U.S. has been least affected by economic swings over the years. When the economy is good, most manufacturers prosper and are not likely to seek cost savings in materials. However, when the economy is poor, manufacturers strive to reduce their cost of material or labor, and plastics today is the material of choice. Plastics can be combined with other polymer materials to form composites for the necessary higher melt points, lighter weights and higher strengths. The trend today is for plastics and composites to replace products once made of metal. Some once-popular all metal items, which today are made of plastics or composites, include the connecting rod of some diesel engines, automobile leaf springs, many automotive parts, and consumer goods of all types, including the 50 typical plastic items one would find in the kitchen.

Plastics Opportunities for Dayton Area

The greater Dayton area has an opportunity to become a world leader in the field of plastics, composites, and possibly nanotechnology. Dayton has many government, state, and commercial research facilities dedicated to developing new materials,

materials production, or to the writing of grants to support research in high-tech industries. These research organizations include:

- **Air Force Institute of Technology (AFIT)** – A Dayton military technology training school with a focus on new high-tech materials located at WPAFB.
- **Air Force Research Laboratory (AFRL)** – Located in Dayton to advance its research and technical leadership in support of the U.S. Air Force's mission to promote strong light-weight composite materials and manufacturing methods.
- **Battelle Institute** – A Columbus research organization exploring new materials and technology. Battelle is a diverse research institute with many capabilities.
- **EMTEC** – Edison Materials Technology Center in Dayton, Ohio provides research, grant writing, and management expertise in support of Ohio's manufacturers. They take projects from "imagining through market entry."
- **Ohio Aerospace Institute** – Located in Dayton to advance the aerospace industry in Ohio with new and existing composite materials.
- **PolymerOhio** – An Edison organization headquartered in Columbus, Ohio where they support the polymer (resins, plastics, composites, nanocomposites) industry located in Ohio.
- **The National Composite Center** – Headquartered in Dayton with a national focus on composites being developed from an incubation stage through product commercialization.

- **Universal Technology Corporation** – A Dayton technical management organization working with new materials and manufacturing concepts.
- **University of Dayton Research Institute (UDRI)** – Located on the campus of the University of Dayton where research of materials and application is tested and developed.

These research and development organizations are innovative in producing new materials and new process technology and they lead development in this high-tech field (Edison Organizations, 2008). It is evident that the area of manufacturing growth is in the high-tech plastics and composites area compared to the declining materials like steel and their processes. Eventually this new innovation translates into manufacturing needs and entrepreneurism. As the manufacturing needs grow the research facilities have two opinions. They can outsource manufacturing locally or to some distant location. The sources they choose will need the technical capability to meet their manufacturing needs. This is where SCC is uniquely positioned within the Dayton area to teach these manufacturing needs. For local manufacturers to compete for these manufacturing opportunities, they need technical employees who have the knowledge and skills in this high-tech field. SCC needs to offer and teach the needed curriculum to support high-tech materials. Currently, no local college offers a complete plastics and composites technology curriculum.

Skills Gap Defined

The term, “skills gap” has many definitions. One definition by The Society of Manufacturing Engineers (SME) defines “skills gap” as the difference between the skills a person possesses and the skills required to do their work tasks efficiently (SME, 1997). One strong skill that SME recognizes is that competent employees have “hands-on” work experience, in addition to technical knowledge to perform at a high skill level.

A “skills gap” in education is the measurable difference between what an employer needs (the demand side) in a skilled person and what the educational institution is teaching (the supply side). For this proposal, “skills gap” is referring to the employer’s needs or the demand side in education. The term, “skills gap” is general and difficult to measure in business and in academics due to its broad coverage of subject matter. To determine the skills gap relative to the duties and tasks of a plastics technologist, an occupational analysis is needed to provide results that are easier to measure and define.

History of Skills Gap

Throughout history ever-changing technology has put education in a position of constantly playing catch-up. A skills gap, small or large, will always exist for a plastics technologist in the U.S. Up until the 1980s technology developed at a slower pace, and companies had little trouble keeping a skilled workforce. The technology change that took place then happened over a long period and companies had on-the-job training, apprentice programs, or technology courses to develop the unskilled workforce. This is how Sinclair Community College (SCC) got started, by satisfying an educational need for local industry (Orenstein & Walter, 2004).

In the late 1800s, industry was expanding in the Dayton area and this generated a need for a skilled workforce (Evanciew & Wither, 2004). This need brought an influx of workers; both skilled and unskilled, looking for work (Greater Dayton, 1996). For workers to obtain the needed skills that manufacturing required, a school was needed with course offerings that matched industry needs. Thus, SCC was founded, and this allowed local technology education to align itself with the community and meet local industrial needs, by offering courses in mechanical drawing, design and materials. This education exposed students to mechanical drawing that required students to hand-letter, or draw production parts using drawing instruments. This is what the manufacturing companies wanted. At the beginning, courses were based on local manufacturing needs since manufacturing growth had brought the unskilled immigrants to Dayton looking for work (Bauer & Growick, 2003). With the unskilled immigrants receiving education and improving their skills, the companies they worked for prospered. In the late 1950s, a new need for skilled workers in Dayton emerged, when factories were undergoing expansions due to consumer needs. Workers with little skills arrived from Appalachia with their families and went to work (Greater Dayton, 1996). They were called the, “silent minority” (in the video tape) due to the difficulty some had just talking (Greater Dayton, 1996). These Appalachian workers were able to cope in a manufacturing plant because technology was advancing at a slow pace (Evanciew, et al. 2004). Once the Appalachian workers learned their craft, they stayed doing this their entire career with little change. Many semi-skilled workers like farmers and military personnel were easily hired in this era due to a craft they had acquired.

The industrial age focused on "knowing what" and "knowing how" to use skills learned in one context and applied in another context was sufficient for most job positions. With the movement to an information age, these competencies have expanded into the required ability to transform skills learned in one context into the more difficult skills of solving ill-structured problems (Reigeluth, 1999). Becoming more proficient within this new environment means adding, "knowing why" to the “what” and “how” knowledge. This "knowing why" perspective allows employees to see their personal view point combine with others and most importantly, the bigger picture from upper management’s perspective. Thus, communication in this new age is important.

Today’s Advanced Technology

As technology advanced many employees were left behind with obsolete or poor job skills that cost companies money. Today, the skills gap is driven by new technology and the high level of knowledge required to compete globally. The technology is more quickly developed and applied, and the vastness of today’s technology is hard to comprehend for even some of the experienced manufacturing technologists or engineers. In the past, companies had one or two choices for manufacturing processes; today they could have ten or more to select from, with each offering many options (Deloitte Development, 2005). Additionally, the choice must be aligned with meeting all the government regulations, (i.e. OSHA, EPA, etc), be cost effective, and meet all customer quality requirements. It takes dedicated workers to stay current with all the new resources, processes, equipment, and types of computerized controls, and then be able to use them to their fullest potential (Evanciew, et al. 2004). As technology advanced, the worker's communication skills also advanced. Some technologists have kept up with all the new technology, processes, and requirements while many have not. For technologists who did not, the skills gap grew wider for them and their employer.

Today's plastics technologists are confronted with an ever growing new manufacturing environment compared to 30 years ago. This new environment consists of advanced technology, new materials, government requirements, good communication skills, project management, and high customer quality standards. These are the areas where the plastics technologists need to be effective for the cost conscious organization they work in today. To be able to perform in this new environment the plastics technologists needs a vast knowledge base and skills their forefathers never embraced.

Technology continues to change while the role of education is always playing catch-up to the current technology. This catch-up difference is the education gap or skills gap. With today's rapid pace of technology it is imperative that this education gap be reduced, whereby the educators are providing the appropriate curriculum that business needs.

Studies of Skills Gap

Over the past 20 years, there has been an increasing interest in skills gap. Researchers have found that the skills gap is hurting the manufacturing sector, business, and our economy. Several researchers conducted studies to evaluate the skills gap concerns in manufacturing. The state of Kentucky's KMSS, two SME studies, and two dissertations studies (using the DACUM process) were found along with other general skill reports. Both the Kentucky's skill standards and SME studies provide very general information on skills gap for general manufacturers. However, the two dissertations were specific studies on duties and tasks of plastics technologists in the plastics industry. Each of the five studies was conducted to determine manufacturing skills gap. However, each had a different outcome when answering the question: "What are the duties and tasks employers need in the greater Dayton area for plastics technologists?" The other general skills report addresses the need for higher skills in manufacturing.

Each of the studies found some skills gap and the studies contained various levels of instrument reliability and validity. In addition, there are concerns of how closely the data they obtained actually matches the plastics technologist's needs in the greater Dayton area.

Kentucky Manufacturing Skill Standards

In 2000, a workforce study program started in Kentucky high schools. This is called the, "Kentucky Manufacturing Skill Standards" (KMSS) program and it tests students in courses taken in the field of manufacturing. This is a state-wide program. The KMSS program surveys students, ages 17 and 18, as participants who have very little, if any, hands-on manufacturing exposure (Kentucky Department of Education, 2007). Here, the students surveyed indicated general categories of skills they received while in high school. Because input from high school students who had no industry experience was used, the reliability and validity of this survey is questionable. This skills standard survey could be the start of a longitudinal survey.

The KMSS program has surveyed inexperienced high school students about manufacturing skills. The survey covered general manufacturing and not a specific occupation like a plastics technologist.

Society of Manufacturing Engineers

A more serious study was conducted by the SME (1996) to determine skills gap in manufacturing. This study was conducted due to a strong focus on manufacturing's role in the American economy. It was noted that manufacturing accounts for 17% of the Gross Domestic Product (GDP) (SME, 1997). Maintaining this GDP requires that the U.S. keep manufacturing in this country, and that requires high technical skill levels. This study determined general categories of skills; however, the expert panel that was used for the study was too far removed from the working technologists or manufacturing engineer on the floor.

This was one of the first manufacturing organizations to see first-hand global change in the U.S., where levels of higher technical skills were warranted (SME, 1997). This started a national survey by SME over two years, to determine the skills gap in manufacturing (SME, 1997; SME, 1998; SME, 1999). The survey attempted to determine the skills gap for manufacturing technologists or manufacturing engineers (sometimes called manufacturing practitioners) by using a panel of experts. The four groups of panel experts were: Vice Presidents or Directors of Manufacturing Managers, Manufacturing Practitioners (age 22 – 30), Manufacturing Practitioners (age 31+), and SME VIPs. These panel experts were representatives from 3M, Caterpillar, Detroit Diesel, Boeing, Ford, and Master Chemical (all large companies with thousands of employees). In the workshops the panel experts used surveys and found general categories and competency gaps or skills gap. These general categories did not include specific duties or tasks of any one particular occupation. Instead, the survey covered all practitioners classified as manufacturing engineers or technologists.

The SME research procedure had each panel expert identify competency gaps, or the skills gap that now exist between workforce needs and the knowledge and skills currently being taught in educational programs. SME found six major areas, with each area broken down into sometimes eight detailed topics. The six major areas were: communication, problem solving, personal attributes, manufacturing processes, product engineering, and engineering sciences. For example; the "communication" major area detailed topics included: writing, presentation, listening, data gathering, and teaming. Each major area was prioritized, along with the detailed topics, into a needs matrix for different education levels. These degree levels were: associate's, bachelor's and masters's.

One strong experience cited by the SME panel of experts as necessary to close the competency gaps (skills gap), was "a need for hands-on experience as an important aspect of the education of the manufacturing engineer or technologists (SME, 1997)." This hands-on experience reduces the learning curve once the technologist or engineer starts working for an employer. The Japanese technologists' students are spending more than 70% of their time in labs doing hands-on activity to speed up the learning process (Craft, 2005). At SCC the faculty says to students, "I hear and I forget, I see and I remember, and I do and I understand." Thus, all MET courses taught at SCC have hands-on activities.

Two years later, the study was repeated by SME to determine if new skills gap emerged. This resulted in some major categories changing their prioritized position since the 1996 study. Both SME studies were conducted the same way with an expert panel and they surveyed general manufacturing and not the plastics industry relative to plastic technologists. The findings were as follows:

1998 Results	**1996 Results**
Business knowledge skills	Communication skills
Project management	Teamwork
Written communication	Personal attributes
Supply chain management	Manufacturing principles
Specific manufacturing process*	Reliability
Oral communication/listening	Project management
International perspective	Manufacturing processes
Manufacturing process control	Business skills
Manufacturing systems	Quality
Quality	Change management
Problem solving	Statistics and probability
Teamwork/working effectively with others	Ergonomics (human factors)
Materials	Materials
Product/process design	Continuous or lifelong learning
Engineering fundamentals	

* hands-on experience in at least one process

Table 2.2: SME Study Results (major categories presented in rank order)

One observation made with both surveys is the category areas for the 1998 survey tend to reflect education needs of a higher business nature, like “business knowledge skills” and ”supply chain management” as opposed to the traditional manufacturing categories in the 1996 survey. This could easily be explained due to the distance the expert panel is from the occupation of manufacturing engineering or technologist. This could also endanger the reliability and validity of the survey instrument.

The SME manufacturing studies found major categories of skills gap for general manufacturing technologists or manufacturing engineers. This was a national study with general category areas found and prioritized. Comparing the 1996 study results to the 1998 results, some major areas changed while others were added or dropped. The 1998 study tended to reflect a business tone where the 1996 survey had more of a manufacturing tone. As the outcomes varied, it is difficult to suggest what the most important skills gap areas are without further study. SME did suggest that educators collaborate in their efforts to teach major category areas from both studies.

General Skills Reports

In his 2006, State of the State address, Governor Bob Taft of Ohio said, “Most good jobs require higher skills levels today than they have in the past in large part due to the increased importance of technology. In manufacturing, for example, more than 40 percent of factory jobs will require post-secondary education by 2012” (Taft, 2006,

p. 1). The National Association of Manufacturers (NAM) has called for expanding programs that encourage high school students to take rigorous academic courses to close the skills gap. In addition, Governor Taft has worked to implement education initiatives focusing on student success at all levels. Taft also said, “The focus is on training in technical skills modern employers need. Ohio must dramatically increase the numbers of students who are prepared for success in college and work. The shift from a largely agricultural and traditional manufacturing economy to the new knowledge economy demands workers with strong skills in math, reading and writing; the ability to communicate clearly, work in teams to solve problems analytically, as well as the ability to gain technical knowledge throughout their careers” (Taft, 2006, p. 3). By educating our students with the correct skills, our students in engineering and engineering technology will prosper, and this, in turn, can help the local community. Also, Governor Taft’s Education Policy message spoke of how the new knowledge economy demands that workers strive for lifelong learning, to maintain a healthy attitude towards work and support their companies’ business goals and needs. Thus, higher levels of problem solving, and other skills needs for businesses, suggest a required curriculum change at SCC. One curriculum improvement that captures problem solving along with other skills is the plastics technology program. Earls & Holbrook (2007) described the importance of STEM (Science, Technology, Engineering and Mathematics) in a recent conference at SCC. In this conference, Ms. Holbrook presented highlights from the Science and Mathematics Education Policy

Advisory Council, where the importance of STEM was being stressed. "To attract and retain 21st century business – and to create and sustain high-skill, high wage jobs – Ohio must meet this talent challenge" (Earls & Holbrook, 2007).

Recent articles from many sources are highlighting facts about skills gaps, talent shortages, and keeping the U.S. competitive. Scholarly journal articles include: (Bank of America, 2008; Florida, 2004), books include: "Rising Above the Gathering Storm," (National Academy, 2006) and Hayes, Pisano, Upton, & Wheelwright (2005), "Operations, Strategy, and Technology: Pursing the Competitive Edge," government data include: (Office of Workforce Development, 2006; President Bush Addresses NAM, 2006), and professional organizations include: (DTMA, 2007; NAM, 2003; NAM, 2007; SME, 1998; SME, 1999). "The U.S. Department of Education estimates that 60 percent of all new jobs in the 21st century will require skills that are possessed by only 20 percent of the current workforce" (National Commission on Mathematics and Science Teaching for the 21st Century, 2000; Office et al. 2006).

The employment forecast for Ohio will remain unchanged through 2014. This is due to the high concentration of employment in the manufacturing sector. Within this manufacturing sector is "traditional" manufacturing which is hiring at a slower rate than the high-technology industries. Ohio accounts for 3.6 percent of U.S. GDP and the forecast is that the population and labor force will grow in Ohio, but the labor force in the entire manufacturing sector will decline (Office et al. 2006).

Battelle has identified four areas of core technology and research strength in Ohio: advanced materials; advanced manufacturing technologies; power and propulsion; and information technology (Ohio labor market, 2008). In this same report, the BLS has indicated what are high-technology and “less intensive” industries. High-technology industries purchase less intensive industry product as an input to their production process. These less intensive industries are: plastics, agricultural chemicals, and motor vehicles, etc. (Ohio labor market, 2008). In the manufacturing area of advanced materials, the field of plastics is developing many new materials annually. The growing field of plastics in Ohio includes polymers, resins, composites and nanotechnology (Deloitte Development, 2005; National Science and Technology Council, 2007; TPP, 2004).

What is most important is a specific study to determine duties and tasks of the plastics technologists in the greater Dayton area? All of the studies cited explained their survey of workforce skill gaps, but none of the surveys provided the information Dayton, Ohio could use for smaller sized plastics manufacturers. SME’s surveys had an expert panel from large organizations with thousands of employees world-wide who were high level manufacturing practitioners, including Vice Presidents, Directors of Manufacturing, and Managers. The SME studies were too general and covered the entire U.S. at a time when many manufacturing companies had not ventured to move off-shore. The KMSS program used high school students for their survey of manufacturing skills gaps rather than plastics technologists who are in manufacturing today. The two dissertations about the plastics industry fell short in today's global marketplace. Both these dissertation studies took place in 1993. The proposed research study is focused on the duties and tasks needed by plastics technologists who work in the greater Dayton area in companies with more than 50 employees. Today, plastics technologists need to know more about CNC controls and automation techniques and they must have broader knowledge about materials, OSHA, and EPA concerns. They also need good communication and knowledge skills (McDaniel, 1993; Tillery, 1993).

Plastic Technologist Duties and Tasks Studies

Two 1993 dissertation studies of plastics technologists determined duties and tasks in the Michigan area and identified competencies in the plastics industry in the Carolinas. The term, "tasks" means the same thing as the term, "competencies," more or less. "Duties" are general areas of competence. In both studies, the DACUM process was used to determine duties and tasks or competencies.

In the Michigan study, 13 major duties and 135 tasks were determined and rank ordered. The study determined entry level (yes or no), importance of tasks, frequency of performance of tasks, and degree of difficulty of task. It was suggested that the study be the basis for designing a systematic approach to the training of industrial plastics technicians. The word competencies in the Carolina study referred to the 8 duty areas they found and the 40 specific competencies referred to the tasks. A survey instrument was developed and 193 randomly selected industry personnel plus 30 plastics educators were chosen as the population. Besides determining competencies, the DACUM survey was determining if plastics' educators and plastics' industry personnel share the same perception regarding competencies. The conclusion was that the two parties do not share the same perception regarding competencies. One-third of the duties identified by the plastics industry personnel were different in comparison to the educator's responses.

Each 1993 dissertation study determined general areas of duties and tasks (competencies) using the DACUM process and targeted the plastics technologist occupation. Both studies identified similar duties and tasks that defined the duties and tasks of plastics technicians/technologists in Michigan and the Carolina areas. These studies are 15 years old and therefore reflect the older technology of the day.

One interesting conclusion in the Carolina study was that the employers duties compared to the educators duties were off by a gap of one-third. Other researchers have estimated that the education gap between what employers need and what they get is often 40 percent or more (Norton, 1997). One recent dissertation using the DACUM process found the educator to employer gap to be 41 percent in the occupation of business (Tomlin, 2003). Tomlin's study (as cited in Szul & Moore, 1999) found that over a five-year period, 175 competencies in a business program needed updating and that curricula, to be relevant and effective, must be continually evaluated.

Occupational Analysis

The researcher found three most appropriate concepts for occupational analysis. To gather data in survey research one uses interviews, questionnaires, or focus groups with each approach offering differences. The methods explored are: personal interviews, the Delphi method, and the DACUM process. Each of these methods collect data. The researcher found each method had different capabilities, thus each is reviewed to describe their strengths.

Personal Interview

The personal interview method has been around for over 50 years and consists of a face-to-face, telephone or other electronic means form of communication. Some electronic means include: interactive television and e-mail forms. The interview is flexible for the interviewer and allows for observing the responder in their natural manufacturing setting. In occupational analysis the main reason for an interview is to determine from a practicing plastics technologist, "What do you do in the workplace?" Generally, using the manufacturing location for the interview will provide for a more relaxed responder and the response rates of 90 percent are obtainable (Ary, Jacobs, Razavieh & Sorensen, 2006). Other advantages include: greater control over the order of questions and this method works for subjects who can not read. The main disadvantage of the face-to-face interview is the higher cost compared to other survey methods. The interviewers need to be properly selected and trained and their travel to the manufacturing sites makes this method costly. It takes a large amount of time to contact responders, make the appointments, and conduct the interviews. Interviewer bias is another disadvantage.

The interviewer is critical to data quality because they administer the questionnaire and the opportunities for mistakes are many even with trained interviewers. These mistakes cause loss of consistency or reliability of the survey instrument. The interviewer may lead the technologist by suggesting a possible answer, the interviewer's interpretation of the technologist's answers could vary from others being surveyed, and interviewers could bias technologists by the image the interviewer projects. Dillman & Salant (1994) wrote, "If they (technologists) perceive the interviewer as being natural, they may be more willing to answer honestly." Social desirability bias from the technologist is another problem. This is where answers from the technologist are socially acceptable responses to please the interviewer. However, the technologists would have answered with different responses with an anonymous questionnaire (Ary et al. 2006). This creates inconsistency in comparing answers from all technologists.

Telephone and other electronic means of interviewing offer lower costs, faster completion, and response rates may reach 80 percent (Ary et al. 2006). A disadvantage is not being able to observe the responder, who could be distracted. In the responder's natural setting the interview could be taking place during meal time, while driving a car, or during a sports event and they may care very little about the answers they provide.

Thus, the personal interview method does not offer a good choice for questionnaire reliability or consistency with responders.

The Delphi Method

The history of the Delphi method dates back to World War II, when the U.S. military was seeking future technological capabilities and strategic planning information. Military groups would communicate with each other by phone or mail. This had many shortcomings, but did emerge as a method of forecasting as compared to traditional methods. Years later, in the 1950s, the "Delphi" method, as we know it today, was developed in the RAND Corporation, and then identified as, "Project Rand" (Linstone & Turoff, 2002).

The Delphi method starts by selecting a panel of experts chosen based on expertise in a given field. These experts communicate by telephone, mail or today one could use e-mail or teleconference calling. In the past, the panel members did not get to visually see the other panel members and in some cases did not know who the others were. They kept the communication going on an individual basis in rounds (usually six) where everyone participated with input. The panel members start with suggesting topics that are scored on a Likert (0 through 5 usually) scale, relative to the question being asked. For each round, the facilitator works with each panel member separately and adds more topics, based on feedback from the other panel members. After each round the Delphi administrator usually scores each panel member's topic response to determine all the responding panel member's mean, range, and standard deviation. After six rounds, the facilitator combines all scoring for the statistics needed. For each round, the facilitator works with each panel member; however, this method is very time consuming and lacks depth in discovery due to the non-interaction of panel members, who are at different locations throughout the process of gathering data.

The Delphi method is chosen for its reliable and creative exploration of ideas and decision making information. This is a structured process of collecting knowledge from a group of experts in a confidential way. Each expert shares common experiences, has a vested interest in the outcome and may have different opinions. This technique consists of several rounds of questions presented to the panel of experts, who are experienced in a subject area that matches the area of interest. This method yields comprehensive information and facilitates consensus among the experts; however, validity of data is lacking due to no verification of data received and the process is time consuming to administer.

The DACUM Process

The DACUM process dates back to the late 1960s in Clinton, Iowa and the 1970s in Canada, where job analysis was researched. The outcome of this process is called DACUM. Some 33 years ago, Dr. Robert E. Norton, at The Ohio State University, learned of the DACUM concept and began to further develop and expand its use. Today, DACUM has many uses; most importantly, it is a fast and high quality process, carried out in approximately two days rather than the weeks used in the Delphi process.

The DACUM process is quicker and more accurate than the personal interview and Delphi methods. The DACUM process is also less costly, making it more efficient. In addition, the DACUM process produces data in the form of duties and tasks that are suited for developing a verification survey instrument. After analysis of the verification survey instrument the application of the SCID (Systematic Curriculum and Instructional Development) process then enables the development of the needed curriculum to fill the gaps identified on the supply side. This descriptive research only analyzed skill gaps on the demand side (the manufacturer) and did not include the development of curriculum.

The DACUM expert panel members see each other face-to-face, which speeds up the process and makes a more complete study. Results include duties, tasks, general knowledge and skills needed, behavior attributes, and other information, providing a more complete study. The expert panel members reach a consensus on all duties, tasks, etc.

The task verification process involves identifying the most important questions (usually two or three) to be asked and then developing a questionnaire where respondents rate each task on each question. Company management selects their top performing person in the occupation being studied to receive the task verification questionnaire. The task verification questionnaire (survey instrument) is administered to the selected employees. The survey results are analyzed using basic statistical analysis. The researcher used expert panel consensus throughout the DACUM process. The obtainable response rate for the verification of tasks usually is 65 percent or better.

Occupational Analysis Summary

Three occupational analysis methods were reviewed for this study. Each method has advantages and disadvantages. DACUM appears to be the best method for determining the duties and tasks of an occupation. Ary et al. (2006) indicate that interviews work well if lower response rates (60 percent or less) are acceptable and the high cost of interviewer training and interviewer time to conduct interviews is acceptable. The interview method has a disadvantage of no responder anonymity, interviewer bias, and is costly to conduct. Little information was available concerning reliability and validity of the interview survey instrument. The Delphi process produces a survey instrument but does not easily and quickly offer a reliable and valid survey instrument (Linstone & Turoff, 2002). The Delphi consensus process has improved throughout the years due to the modern day face-to-face teleconference process. However, this may require several rounds of questionnaires available to all Delphi responders.

To keep costs down, the survey instrument needs to be administered quickly, be of high quality, and be verifiable to insure that a reliable and valid survey instrument is being used. Over the years the DACUM process has proven itself to be a reliable method for occupational analysis in determining duties and tasks with an expert panel of practitioners. The resulting duties and tasks are used to develop a high quality verification survey instrument. This high quality verification survey instrument can be improved for clarity by additional expert panel or field review.

Conclusion

This review of literature section has contributed information that shows need for a survey to determine what plastic technologists need to know in manufacturing today. The history of plastics indicates that polymers are the largest and fastest growing class of advanced materials in the world and a skills gap in the U.S. does exist in most business sectors (Liston, 1995). The history of employee skills gap in the greater Dayton area further verified that yesterday's industrial age of, "knowing what" and "knowing how" to use skills learned was sufficient for most jobs. Today, employees need to add, "knowing why" and integrate their thoughts with others in the information age. The skills required have expanded into abilities to transform skills learned in one setting into the more difficult skills of solving ill-structured problems (Reigeluth, 1999). The rapid growth of advanced materials, processes, and the shift from an industrial age to a knowledge and communication age have created a skills gap.

With the "history of skills gap" in most industries and changing technology in the U.S. it becomes apparent to understand a particular occupation's skills gap and assessment is needed to determine the extent of this gap. In assessing the available skills gap studies on competencies, duties and tasks, the reviewed literature was very general when the researcher was seeking the specific occupation of plastics technologists. The duties and tasks that were identified in the dissertations helped to identify some tasks, however these surveys were 15 years old and did not account for the new technology we have presently. Within the last 10 years new process technology has emerged where manufacturers are using plastic processing equipment (plastic injection molding machines) to produce ceramic and metal parts. Other reports on plastics education deficiencies involving STEM indicated further gaps in education and skills. This manufacturing occupation and education gap occurs at a time when the U.S. needs technologists and SCC needs to know what skills manufacturing employers' need. Based on the literature review, a demand exists for plastics and plastic related products (composites) in the Dayton area. This demand occurs while SCC has met a lower budget expectation which has forced a reduction in the plastics program. Today, this reduction raises questions about meeting the needs of local industry.

The local skills gap should be identified through an occupational analysis like the DACUM process. The results of the DACUM workshop should then be used to develop a task verification survey instrument with high reliability and validity. Once the gaps are identified, educational courses can be developed, or course content modified to fill the manufacturers' needs for their new hires and other employees.

There are many employment opportunities in the greater Dayton area for skilled plastics technologists (Deloitte Development, 2005; TPP, 2004). These employment opportunities are projected to 2014. A survey of plastic technologists' duties and tasks needs to be conducted to determine the demand side.

After evaluating the three occupational process analysis methods, the researcher concluded that the DACUM process was the most effective, the fastest, and most economical method available. Over the years, Dr. Robert E. Norton has conducted hundreds of DACUM job analysis workshops. This history of occupational job analysis using the DACUM at The Ohio State University indicates that an occupational analysis of a plastics technologist was achievable. Furthermore, the DACUM produces data that can be used in the task verification instrument. This leads to improved content validity by using data produced by an expert panel. Further field reviews and pilot testing can establish reliability of the survey instrument. Thus, the researcher selected the DACUM process for this occupational analysis.

CHAPTER 3

METHODOLOGY

Introduction

This descriptive research explored and identified the duties and tasks of plastics technologists in the greater Dayton area. As a part of this study the researcher conducted a DACUM workshop and then used a verification survey questionnaire to gather data from practicing plastics technologists. The DACUM workshop determined the duties and tasks of a plastics technologist. The survey determined whether an entry level plastics technologist performs each task, the task importance, and the task difficulty. Then, ratings of the importance of selected enablers in the categories of general knowledge and skills, worker behaviors, tools, equipment, supplies, and materials completed the survey. The gathered information was analyzed using descriptive statistics to determine the ranking of each task and the enablers.

After being developed, the task verification questionnaire was mailed to the plastics practitioners and quantitative data was gathered from the survey questionnaire. This study captured valuable data about what the duties and tasks are for plastics technologists on the demand side. In addition, the study provided SCC with relevant information to consider for possible future curriculum improvement. The focus of the study was to measure what skills that manufacturers require of a plastics technologist

Research Design

This descriptive research study had a planned timeline (see Appendix G) and three phases of execution. Phase I consisted of conducting a DACUM workshop with an expert panel in order to identify their duties and tasks. Phase II consisted of development of the verification survey instrument and pilot testing, followed by Phase III, where the survey was implemented. The implementation included the sampling of company plastics practitioners, sending out a survey instrument to selected employees, and analyzing the survey data.

Phase I – DACUM Workshop

Upon receiving SCC's IRB approval (see Appendix H), Phase I started with the selection of the DACUM expert panel. A DACUM recorder, security, refreshments, parking passes and a host location were all arranged.

To select the DACUM expert panel, the researcher used convenience sampling from a pool of individuals who were recommended from professional organizations in the Dayton area. These expert panel members were required to be practitioners in plastics technology, with first-hand knowledge in manufacturing and with a minimum of five years of plastics manufacturing experience. The nominations came from the local American Society of Quality (ASQ), the Society of Plastics Engineers (SPE), and the Society of Manufacturing Engineers (SME). Each pool member was contacted by phone, seeking their interest to volunteer for this research project. They were informed about this important curriculum development project and how positive it could be for plastics manufacturers and the community. In addition, they knew in advance they would be signing a letter of consent and be providing personal data and their years of industry experience and education level, with all this information held in confidence. Other qualifications of the experts included some education beyond high school as a minimum, and the ability to bring a new perspective and a positive attitude. Initially, 23 individuals were contacted by phone, to finally secure eight expert panel members. While securing the expert panel, one woman, one African American, one Hispanic, and five others volunteered their time. One additional person from the 23 individuals became the DACUM recorder, while the researcher served as the certified DACUM facilitator. There were no faculty members or observers within the entire expert panel; however, one panel member was a plastics supervisor. The panel members came from small (but more than 50 employees) and large (but less than 150 employees) facilities, with different plastic manufacturing processes and from different locations around Dayton. The average number of employees per facility in the population was 121.

Expert Panel Facts

1. The expert panel had eight members; one female and seven males, one Hispanic, one African American, and six Caucasians.

2. Years of experience as a plastics practitioner: 24.8 years was the mean with a range of 38 years (7 to 45).

3. Education ranged from apprenticeship through Masters Degree with a mean equivalent to more than a two-year Associate's Degree, but less than a B.S. degree.

On January 4th and 5th, 2008, the DACUM workshop took place at SCC, Dayton, Ohio. This date was chosen due to the slower local manufacturing schedule during New Year's week. The day before the DACUM, the facilitator arranged the workshop room with the panel members' tables arranged in a semicircle facing the white board and the recorder's table placed on the side near the white board. All pencils, roster, agenda, name tents, paper, tan (duties) and white (tasks) card stock, masking tape (adhesive putty), flip charts, felt-tip markers (three of each – different colors), and computer with DACUM presentation were also in place. The handouts consisted of: a sample of high quality DACUM chart, task and task statement criteria, verb lists, and workshop evaluation forms.

The DACUM Process

The DACUM process has the following procedural steps after the introduction of the expert panel members, recorder and facilitator (Norton, 1997):

1. Orientation to DACUM
    a. PowerPoint orientation with handouts
2. Review of job or occupational area
    a. Brainstorming the whole job
    b. Organizational chart of occupational area
3. Identification of the duties (general area of job responsibility)
4. Identification of specific tasks performed for each duty
5. Identify lists of: general knowledge and skills, tools and equipment, worker behaviors, and future trends/concerns
6. Review and refine duty and task statements
7. Sequence duty and task statements
8. Other options, as desired

There are different roles for all participants during the DACUM. The role of the facilitator is to orient the panel to the process, guide them through analysis, draw out ideas, question task statements, and keep the discussion and process on schedule. The role of the panel member is to share knowledge and decide what skills are required of those wanting to enter the plastics field as plastics technologists. All decisions by panel members are by consensus. The recorder's role is to assist the facilitator by writing the panel members' contributions on colored card stock. After explaining each role to all the DACUM participants, it was emphasized that each member is very important to this DACUM process.

At the beginning of the workshop and after introductions from all present, a PowerPoint presentation on the DACUM process took place. After the presentation, and after all questions were answered, each panel member signed the SCC IRB human subjects consent form (see Appendix I). Then each person filled out the member identification data sheet (see Appendix J), followed by an eight minute review of an entry level plastics technologist's job by an experienced plastics plant engineer. He emphasized the positive impact it could have for area manufacturers, SCC and students. The facilitator then established the title, definition, and scope of the occupation and reminded them of the research goal: "Identify the duties and tasks that manufacturing employer's need for employees in the manufacturing plastics technologist position."

After roles were explained, the facilitator led the expert panel into a brainstorming activity on the entire plastics technologists' job, and recorded these on flip charts. The whole job brainstorming started at one end of the group and each panel member in turn gave one work activity. The facilitator repeated many times, "What does a plastics technologist do?" After filling six flip chart sheets with work related activity and hanging these in front of the panel, this information was later used to identify potential duty areas.

Next, members were asked to identify job titles within their companies for the occupation under consideration or job titles that reflect related positions. After a few different written responses from the panel, the facilitator drew an organizational chart and sought input from the panel to structure the plastics technologist's position and indicate to whom that position reports to in the company. The panel was also asked to identify internal to the company and external to the company groups that the plastics technologist typically interacts with.

After explaining that a duty is a large area of work with a cluster of 6 to 20 related tasks, the clustering of the whole job brainstormed statements into duty statements began. Duty statements are short in length and should start with an action verb, contain an object, and usually have a qualifier. Duty statements are general statements of work performed and they stand alone. They are not statements of worker behaviors, tools, or knowledge needed. The scope of work for a duty is large, where the scope of work for a task is smaller. The facilitator gave the example of an automobile owner where the duty is, "Maintain automobile engine," and a task is to, "Change the motor oil." The panel worked with the facilitator for about one hour to identify the duties using the brainstormed list of activities as a reference. Once the panel identified all the duties they could, the facilitator reviewed each statement on the brainstormed lists to see if each identified work activity would fit under one of the already specified duties. Items that did not fit were marked and an additional duty was identified to address them. As panel members agreed on the wording of a duty statement, the recorder was asked to write that duty statement on card stock and tape it into position, on the white board. Using consensus from the expert panel, the initial sequencing of duty statements began. The facilitator emphasized that sequencing is an arrangement of duties in a logical and normal work flow order and that duties could change position before the DACUM process was completed. Next, the group reviewed and refined the duty statements before proceeding to identify task statements.

The facilitator asked the panel members to tell what they "do" when performing a particular duty. To start with a duty, the panel brainstormed as many things (work activities) they do to perform that duty as they could think of. Flip charts were used to record the many things they do. These charts were displayed in front of the panel for observation.

Before asking the panel to convert the brainstormed work activities into tasks statements, the facilitator reviewed the characteristics of good task statements. Task statements are short in length, precise, should have a single action verb and an object that receives the action, and usually have a qualifier to clarify the task. The verb must complete the unwritten statement as follows: "The worker must be able to ______" (Norton, 1997, p. D-31). As panel members agreed on the wording of a task statement, the recorder was asked to write that task statement on card stock and tape it into position, on the white board.

Using consensus from the expert panel, the initial sequencing of task statements began. Again, the facilitator emphasized that sequencing is an arrangement of tasks in a logical and normal work flow and these tasks could change position before the DACUM process was completed. The facilitator explained that tasks could be listed only once. If a similar task was to be used twice, then they had to be written so to make their difference clear. Next, the group reviewed and refined all task statements. Before leaving duties and tasks the expert panel was asked to consider rearranging the sequence of duties. One initially was moved, but consensus returned it to its original position.

To develop a high quality DACUM chart, the enablers need to be identified. An enabler statement is a general knowledge and skill, tool, or worker behavior that is essential to the employee's ability to perform tasks. The enabler statements that must be identified are: general knowledge and skills (knowledge needed by workers), worker behavior (attitudes and traits), tools and supplies, and future trends and concerns for the plastics technologists. Like the duty and task statements, the enabler statements are developed using brainstorming techniques. Thus, the expert panel again used a similar process for determining the enablers.

Near the end of the DACUM process, the facilitator obtained final agreement from the expert panel on the DACUM chart, as to the chart being reasonably accurate and comprehensive in describing the work of plastics technologists. Then duty and task statement cards, which had been taped to the white board, were coded A-1, A-2, etc. All statement cards and flip chart sheets were retained for preparation of the DACUM Research Chart.

Upon completion of the DACUM process the facilitator thanked everyone (see Appendix K).

Phase II – Development of the Task Verification Survey Instrument

The outcome of the two-day DACUM process was a list of duties and tasks and related enablers information (see Figure 4.2 – DACUM Research Chart). A task verification survey questionnaire was then produced from these lists (see Appendix L). The questions for the task verification were:

- Does an entry level plastics technologist perform this task? Yes or No
- How important is this task in the performance of the plastics technologist's job? (0 through 5 scale - with 0 being not at all important and 5 extremely important)
- How difficult is it to perform this task as a plastics technologist? (0 through 5 scale - with 0 being extremely easy and 5 extremely difficult)
- How critical are the general knowledge and skills; worker behaviors, tools, equipment, supplies, and materials; and future trends and concerns categories? (0 through 5 scale - with 0 being not at all critical to job performance and 5 extremely critical to job performance)
- A general information sheet pertaining to education level, years of experience, position title, plastic processes currently being used, and demographic information was also provided.

One week after the DACUM workshop, the verification survey was reviewed by three original expert panel members for correctness or additions. No errors were found or changes suggested.

Further field review and pilot testing of the verification survey questionnaire was completed by four experienced plastics practitioners who were not part of the expert panel. The practitioners were asked to read the instructions, complete the questionnaire and determine the amount of time required for completion. During this extensive review the practitioners evaluated the verification survey for feasibility and clarity, and provided feedback. A few small changes were suggested and the researcher modified the survey and sought feedback from three original expert panel members. Upon receiving a consensus from panel members the suggested changes took place.

Phase III - Implementation of Task Verification Survey

After the IRB approvals (see Appendices M and N) the population of companies (see Appendix O) were determined, the verification survey was administered to the plastics technologists in manufacturing. The verification survey was mailed, and non-responders identified for follow-up. Using all returned and properly completed verification survey questionnaires, the analysis of the data was made and reported.

Population

The population of companies was determined from three Ohio manufacturing directories targeting nine Ohio counties. The entire population of companies was selected to receive the verification survey questionnaire.

The population of companies consisted of those listed with more than 50 employees and who directly manufacture plastic products. The benchmark of 50 employees for a survey was recommended by the DTMA due to the following rationale:

- The DTMA (2007) has twenty years experience in surveying their membership (300 to over 600 companies) with high non-response rates from companies with fewer than 50 employees.
- Smaller companies hire mostly entry level technicians due to the small pay they can afford (DTMA, 2007).
- In small companies the president is usually the best practitioner and is busy running the business. This allows little time for this manager to take surveys (DTMA, 2007).

Thus, finding good and experienced plastics technologists with more than five years experience is difficult in small companies. In time the disciplined and experienced technologists leave the small companies for new challenges in the larger and higher paying companies.

Rubber manufacturers, plastic consulting, sales and service organizations were not included in this survey, because they usually do not employ a plastics technologist with production, cost saving and process experience. For this study the plastic processes of interest are: blow molding, extrusion, fiberglass reinforced, injection molding, reaction injection molding, resin transfer molding, rotational molding, and thermoforming. Mold making (tooling) is another closely related process needed for the plastic processes.

All eligible company names came from three different sources and the final list was verified, with no duplicate company names. The population sources came from the following: 2008 Harris Ohio Industrial Directory, 2008 Ohio Manufacturing Directory, and PolymerOhio's 2008 directory of all Ohio manufacturers of plastic product (Harris, 2008; Ohio Manufacturers, 2008; PolymerOhio, 2008).

This research study was conducted within the greater Dayton, Ohio area consisting of the following nine counties: Butler, Clark, Clinton, Darke, Greene, Miami, Montgomery, Preble, and Warren. These nine counties represent about 95% of the SCC's student body (Office of Institutional Planning & Research, 2007). An initial count of 147 companies using the Standard Industrial Classifications (SICs) of 3011 through 3089 were identified within the classification of rubber and miscellaneous plastics. However, this study is focused on the miscellaneous plastics SICs 3081 through 3089 with the exception of SIC 3087 (custom compounding plastic resins). After removing rubber manufacturing and non-plastic manufacturers from the population and selecting companies of the correct size, the final population of companies became 29 (see Appendix O). The average size of the manufacturing companies in the population of those qualified based on production of plastics was 121 employees. The employee size range was from 50 to 710.

Sample Versus Whole Population

Using a random sampling method of companies the sample size was calculated at 28 companies (Gay, Mills, & Airasian, 2006; Dillman & Salant, 1994) with a population of 29. The sample size of 28 targets a 95 percent confidence level with a sampling error of plus or minus 5 percent. This sample size, confidence level, and sampling error were determined by a formula developed by the U.S. Office of Education for descriptive research. With the sample rate approaching the total population and for the small extra cost the researcher chose to survey the entire population of companies.

Population of Companies

A survey of 29 companies was conducted with a targeted response rate of 100 percent. To insure a quality survey of all respondents close controls were maintained and focused on the following potential sources of errors.

1. Selection error was controlled by purging the population list of duplications for any selection error.

2. Frame error was controlled by cross-referencing three Ohio 2008 industrial directories.
3. Non-response error was controlled with follow-ups, personal visits, phone call interviews and finally by interviewing a 10 percent sample of non-responders by phone or in person to collect the data.
4. Measurement error was controlled with clearly stated questions, clear instructions, pilot testing, and field review with a reliable and valid instrument.
5. Sampling error was controlled by doing a surveying the entire population.

Company Contact Process

The company contact process consisted of documenting the company names and recording next to the names a three digit survey responder code. Phone numbers and company address were recorded.

The verification survey questionnaire went to a company management selected plastics technologist practitioner at each company. The plastics technologist could have a variety of education levels, years of experience, skills, and working knowledge. All the plastics technologists, known as subjects, were 23 years old or older. The survey was targeting practitioners with more then five years experience, who are recognized by their company management as performing above a 50 percent performance level compared to their counterparts (other technologists). These persons were recommended to take this survey by their companies' CEO, plant manager, or administrator in charge, hereafter called company manager.

The survey distribution process was started by the researcher phoning a company manager and informing him/her of the plastics survey (see Appendix P – Script to Company Management). The benefits to be derived from this research study were cited and the possibility of the survey participant winning an iPod was communicated. The researcher cited possible improved plastics and manufacturing curriculum focusing on the needed skills for a plastics technologist. In addition, the researcher explained the current national skills gap and how education in STEM (Science, Technology, Engineering, and Mathematics) could improve our global economic standing in the greater Dayton area, in Ohio, and in the country. The time required to complete the verification survey questionnaire was approximately 35 minutes. Then, the company manager was asked, "Could you recommend your best performing plastics technologists for this take-home survey?" The researcher then requested from the company manager, the name or names and phone numbers needed to enable phone contact. If the manager mentioned more than one best performing plastics technologist, each one was therefore contacted. However, the researcher did not contact any best performing plastics technologists named by management who served on the DACUM expert panel. In addition, the company manager was asked if the survey could be mailed to the company address. All the managers contacted did wish to participate.

Each recommended plastics technologist was phoned, and received an explanation of who recommended him/her, the survey benefits, and the possibility of winning an iPod for completing and returning the survey (see Appendix Q – Script to Technologists). The proposed volunteer plastics technologists were asked, “Will you volunteer?” If the answer was “yes,” the researcher requested the mailing address in order to forward the informed consent form (see Appendix S) and task verification survey questionnaire (see Appendix L), along with a cover letter (see Appendix R) explaining how the individual was chosen and what this survey was about. The complete mailing consisted of the cover letter, consent form, the task survey, and a prepaid self-addressed envelope addressed to researcher. After receiving the returned scored verification survey questionnaire, the volunteer received a personal “thank you” letter from the researcher, with a copy going to the company manager. In addition, the responder’s name was entered to compete for the iPod (Dillman, 2000).

Data Collection

Once the survey plastics technologists were identified, the packet containing the verification survey questionnaire, cover letter, consent form, instructions and return mail stamped and addressed envelope, was mailed. The packet was mailed to the company or to the volunteer’s home address, based on the recommendation from the company manager. Each verification survey questionnaire had a three digit code number, which corresponded to the person and company receiving the survey. One mail follow-up to each non-responder was made and finally a reminder phone call was made. A complete packet was sent as the mail follow-up. With the target response rate of 100 percent, non-responders were identified and tracked. With the response rate less than 100 percent, based on the entire population of 29, the researcher interviewed a 10 percent sample of non-responders by phone to collect the data (Ary et al, 2006). There was one non-responder contacted by phone and the responses were compared to the early responders and were found to be similar. This is called, “double dipping” to maximize the response rate. The researcher pursued data collection for 30 days.

Data Analysis

All returned verification survey questionnaires had identification codes removed and were stored in a secure area. The data from verification survey questionnaires was analyzed using SPSS (2007) statistical software and descriptive statistics. For the demographics, occupation titles, and manufacturing processes the descriptive statistics used were frequencies and percentages. This data appears in Chapter 4 tables that describe the population.

The duties and tasks data from the verification survey questionnaires were analyzed using the following main descriptive statistics: percentages, means, frequencies, and standard deviation. The data and its analysis assisted in answering the following research questions.

The **first research question**, “What are the duties and tasks that manufacturing employers need for a manufacturing plastics technologist to perform?” was answered by the DACUM workshop and the development of the DACUM Research Chart by the DACUM expert panel.

The **second research question**, “What are the entry level tasks as indicated by a consensus of manufacturing plastics technologists?” All the identified tasks were analyzed by percentage of responders who answered “yes” and then ranked in descending order. The researcher’s percentage cutoff point of 33.3 or above was arbitrarily selected based on review of literature. The higher the percentage ranking indicates the greater importance that task is for entry level plastics technologists to perform.

The **third research question** has two parts. “How do manufacturing plastics technologists rate the tasks on: A) **importance to the job** and B) **difficulty to perform**?” The “importance to the job” and “difficulty to perform” tasks are presented in descending order based on their means. The means cutoff point of 2.500 or above was arbitrarily selected for part A and B questions based on review of literature. In part A) the higher the means ranking for the task indicates the greater “importance to the job” for the plastics technologists. In part B) the higher the means ranking for the task indicates the greater “difficulty to perform” for the plastics technologists. The duties and tasks were analyzed and rank ordered for importance using a “criticality calculation” (Raymond, 2002). The criticality calculation analyzes each respondent’s scores on three separate measures (Task Performance, Task Importance, and Task Difficulty). This calculation provides a single value for those measures for each person and averages across all respondents for each duty/task combination. The resulting "criticality" product provided an arbitrary useful cutoff point of 9.000 or above for deciding which task is selected for training (see Appendix X – Sample Criticality Calculation).

In addition, each enabler's mean, standard deviation and item response frequency were analyzed. The enablers are presented in descending order based on their mean scores for importance with an arbitrarily selected means cutoff point of 2.500 or above based on review of literature. The higher means indicates greater importance to the job. Small differences between the higher mean scores indicate that these enablers are needed for plastics technologists to perform.

Validity

This research survey was conducted using the DACUM process where expert plastics technologists (practitioners) served on the expert panel and determined the duties and tasks of that occupation.

To validate the verification survey of duties and tasks there are four types of test validity available. They are criterion-related validity, consequential validity, construct validity, and content validity. The most important characteristic of a survey measure or test is validity.

Criterion-related validity is test scores systematically relating to one or more outcomes. The criterion is important when test scores will be used to infer performance. The two forms of criterion-related validity are: concurrent and predictive validity. Concurrent validity evidence is the relationship between scores on the measure and the criterion scores obtained at the same time. Predictive validity evidence is the relationship between scores on the measure and the criterion scores obtained in the future. Neither of these criterion-related validity forms apply for this study. The task verification instrument for this study is intended to be responded to once and to describe the duties and tasks of current plastic technologists.

Consequential validity evidence is the level to which a test instrument creates harm to the test taker based on their answers. Consequential validity allows researchers to identify tests that could be harmful to the test taker. This test instrument's purpose is in determining and measuring duties and tasks and the questions asked are generic, suitable and not harmful. Thus, consequential validity is not a threat in this study (Ary et al. 2006).

Construct validity is proof evidence that a survey measured the intended behavior, feeling, or attitude. A person can not see a construct (intelligence or honesty), but only observe its effects. However, the constructs used in the task verification instrument are all work related duties and tasks of the occupation of plastics technologists. The measurement in this study is on concrete duties and tasks in an occupation and not on the person responding to the survey. Thus, construct validity is not threatened in this study (Fink, 2006).

Content validity involves the task verification instrument's content and the relationship to the constructs it is measuring. For this study the measurement is on the occupational analysis of a plastics technologist.

Evidence for the validation survey questionnaires content validity is based on the expert judgment of the DACUM expert panel (Gay et al. 2006). Ary et al. (2006, p. 440) writes, "The most obvious type of scientific validity evidence is based on content, which may be gathered by having some competent colleagues who are familiar with the purpose of the survey examine the items to judge whether they are appropriate for measuring what they are supposed to measure and whether they are representative of the sample of the behavior domain under investigation." Fink (2006, p. 39) writes, "A survey can be validated by proving that its items or questions accurately represent the characteristics or attitudes they are intended to measure." Fink goes on to say, "Content validity is usually established by asking experts whether the items are representative samples of the attitudes and traits you wish to survey." Two important variables influence the validity of a questionnaire. First, how important is the topic to the respondent? You can assume more valid responses from individuals who are interested in the topic and/or are informed about it. Second, does the questionnaire protect the respondent's anonymity? It is reasonable to assume that greater truthfulness will be obtained if the respondent can remain anonymous, especially when sensitive or personal questions are asked" (Ary et al. 2006, p. 440).

According to Norton (1997), the DACUM operates on the following three premises: First, expert workers are better able to describe/define their job than anyone else. Second, any occupation or job can be effectively described in terms of the tasks that successful workers in that occupation perform. Third, all tasks have direct implications for the general knowledge, skills, worker behaviors, and tools that workers must have in order to perform their tasks correctly and efficiently. The DACUM process results in a list of duties and tasks which are then verified by other workers performing the same job, and possibly by their supervisors.

Thus, 1) the DACUM verification survey questionnaire contained facts, words, and ideas that are commonly used by a plastics technologist, 2) the survey instrument was pilot tested and, 3) the respondent's anonymity was protected. The survey questionnaire content was considered valid using the content validity technique and threats to validity were controlled.

Threats to Internal Validity

The threats to content validity could diminish the validity of the DACUM process and task verification survey. The following are possible threats to internal validity and how they were controlled in this study: (Gay et al. 2006; Campbell & Stanley, 1963).

- Selection of subjects was controlled by researcher to insure subjects were plastics technologists.
- The test location and environment was not controlled by researcher, however the researcher suggested that the survey be taken in a comfortable location.
- The attitude of subjects was not controlled; however two subjects were not sent survey instruments due to not meeting selection criteria. In both cases the researcher went back to the companies and located qualified subjects.

Threats to External Validity

The following are possible threats to external validity and how they were controlled in this study: (Gay et al. 2006; Campbell & Stanley, 1963).

- The survey was conducted in a way that allows replication.
- The threat of unclear test directions was controlled by further field review by experienced plastics practitioners.
- Difficult sentence structure was controlled by writing easy to understand three or four word duties and task statements and by further field review of the task verification survey (Gay et al. 2006)

Reliability

A test is reliable to the extent that the measure yields consistent results and the scores are free of random error (Ary et al. 2006). There are a few reliability coefficients available including: test-retest, equivalent-forms, and internal-consistency.

The test-retest coefficient is derived from correlating individual's score on the same test, but at different time intervals. For equivalent-forms the coefficient is obtained from correlating individual's scores on different sets of equivalent characteristics. The internal-consistency reliability of the verification survey questionnaire or survey instrument is a measure of reliability of different survey items intended to measure the same characteristics. Of the three mentioned, the internal-consistency coefficient is the only one where a single administration of the test is required (Ary et al. 2006). The other two require two administrations. Due to a short survey time period internal-consistency reliability was used.

Within internal-consistency measures are: homogeneity measures, Cronbach's alpha method (coefficient alpha), and the Kuder-Richardson method. The homogeneity measures the interitem consistency of the items. Cronbach's alpha method is similar to the Kuder-Richardson formula 20 method and describes how well different items complement each other in their measurement of the same quality or dimension. The Kuder-Richardson formula 20 method is applicable to tests where the items are dichotomous (0 or 1). However, the Cronbach's alpha method has wider applications than the Kuder-Richardson formula 20 method and it does homogeneity measures. When the Cronbach's alpha method has items scored dichotomously, it yields Kuder-Richardson formula 20 method results. Due to the single administration of the verification survey questionnaire and with some tasks questions scored dichotomously plus the seeking of homogeneity, the coefficient alpha, or Cronbach's alpha will be used to determine internal-consistency reliability. Cronbach's alpha method ranges in value from 0 to 1 and the higher the score, the more reliable the verification survey questionnaire becomes. An alpha measure of 0.7 is considered an acceptable reliability coefficient for internal consistency. To calculate the coefficient alpha, the variance of all the scores needs to take place. All data was entered into SPSS (2007) v. 16.0 software, which has a coefficient alpha as the index of reliability.

Summary

This chapter described the methods and instruments used to determine the skills needs of plastics technologists in the greater Dayton area. After the introduction, the research design was explained, followed by the DACUM process through which plastics technologist's duties and tasks and related enablers were determined. The verification survey instrument was developed from the results of the DACUM process. The findings from data collected and analyzed should assist SCC and its faculty in curriculum improvement. Chapter 4 explains the method of comparing the demand side to the supply side that SCC uses for curriculum improvement.

CHAPTER 4

DATA COLLECTION AND ANALYSIS

This chapter covers data collection and analysis from a survey of the greater Dayton, Ohio area plastics manufacturers, as detailed in Chapter 3. Each plastics manufacturer and targeted plastics technician was screened to ensure they met the criteria of the study and then mailed a survey. A population of companies, as opposed to a sample, was used. There are five sampling errors of survey research. By surveying the whole population selection and frame errors were not a threat to the study. Measurement error was controlled with high reliability and validity of the instrument and was explained in Chapter 3. A survey of the whole population avoided random sampling error. This left only non-response error as a potential threat. In a survey of the whole population the values of the population are called parameters as opposed to sample statistics.

Non-response error was handled through the follow-up letters (see Appendix T) and using the "double-dipping" method. Of the 29 target companies two surveys were responded to, but were not used for this study. One potential responder declined to fill out the survey so the researcher interviewed this person by phone and used the "double-dipping" method. Based on the data collected the researcher had no reason to believe this non-responder was not responding due to some concern with the characteristics of interest and assumed that this non-responder was like those who did respond on the characteristics of interest. Another company responder requested another survey mailing after a follow-up phone call. This person marked the instrument with mostly zeros and a few times circled numbers when no task was identified. This was the last survey received and was not thoughtfully marked like the other surveys. The researcher discarded this last survey by classifying it as a highly suspect outlier (a rare chance event). Thus, with a 100 percent response rate due to "double dipping," (Dr. Larry Miller at The Ohio State University - conversation of July 1, 2008) the researcher actually used 93.1 percent of the survey responses in this study.

The survey instrument reliability was strong with a measurement of 0.968 using Cronbach's Alpha with a N of 234 items – (see Tables 4.1 and 4.2), further validating the DACUM process results. The content validity was based on the expert judgment of the DACUM panel in the development of the tasks and duties and with their review of the survey questionnaire. The DACUM verification survey questionnaire contains facts, words, and ideas that are commonly used by practitioners, the survey instrument was further reviewed by other experienced practitioners, the respondent's anonymity was protected, and threats to internal and external validity were controlled.

	N	Percent
Cases Valid	26	96.3
Excluded	1	3.7
Total	27	100.0

Table 4.1: Cronbach's Case Process Summary

Cronbach's Alpha	N of Items
0.968	234

Table 4.2: Cronbach's Reliability

The research findings are based upon the results of a DACUM workshop and the development and administration of a task verification survey instrument. The purpose of the DACUM workshop was to obtain a list of the duties and tasks considered to be essential to the success of industrial plastics technicians. Eight panel members, experienced as plastics technicians, participated in the workshop and developed a list of 11 duties and 78 tasks that a plastics technologist needs to be successful. This led to the development of the high quality task verification survey instrument, which was further tested and modified to ensure completeness and clarity. The survey instrument was printed and mailed to 29 industrial plastics technicians or supervisors (responders) who were identified by company managers.

The responders were asked to indicate for each of the tasks whether this was done by entry level plastics technologists, the task's importance to performing their job, and the task's difficulty in performing. Each respondent was asked to indicate his/her job title, number of years in that position, the number of years of plastics experience, the highest level of education completed, and identify the plastic processes their company uses. The following tables summarize this data.

Table 4.3 indicates the number and percent of companies currently involved in each plastics process. Both primary and secondary processes were indicated. The data indicates 51.8 percent are injection molders representing the most frequent response group. The highest secondary process is mold making where 42.8 percent perform this high skill.

Plastic Processes	**Primary**	**Percent**	**Secondary**	**Percent**
Blow molding	1	3.7	0	0
Extrusion	4	14.9	2	9.5
Fiberglass reinforced plastic	3	11.1	1	4.7

Continued

Table 4.3: Company Processes

Table 4.3 continued

Plastic Processes	Primary	Percent	Secondary	Percent
Injection molding	14	51.8	3	14.4
Mold making	0	0	9	42.8
Reaction injection molding	1	3.7	4	19.1
Resin transfer molding	1	3.7	0	0
Rotational molder	1	3.7	0	0
Thermoforming	1	3.7	2	9.5
Other - Plastic dip molding	1	3.7	0	0
Total	**27**	**100**	**21**	**100**

The data in Table 4.4 reveal the number and percent of respondents based on job title. Of those responding 40.8 percent indicated a job title of plastics department manager. In contrast, only 29.6 percent indicated a job title of supervisor, and 11.1 percent were engineers or technologists. The information is based on job title given by respondents from the task verification survey. The titles varied with the category named other being identified as foreman.

Titles	**Number**	**Percent**
Plastics Department Manager	11	40.8
Supervisor	8	29.6
Engineer	3	11.1
Technologist or technician	3	11.1
Maintenance	1	3.7
Other - Foreman	1	3.7
Total	**27**	**100**

Table 4.4: Job Titles of Responders

Table 4.5 provides information relative to the number of years respondents have worked with their company. Of those responding 51.8 percent have 11 to 15 years with their company, 25.9 percent have 6 to 10 years. Current company experience in the 6 to 15 years group with 77.7 percent of the respondent strongly suggests that these plastic practitioners do not change jobs from one company to another often.

Number of Years Range	**Number Responding**	**Percent**
Less than 5	0	0
6 to 10	7	25.9
11 to 15	14	51.8
16 to 25	4	14.9
26 to 30	1	3.7
Greater than 30	1	3.7
Total	**27**	**100**

Table 4.5: Years Experience with Current Company

Table 4.6 indicates the years of experience in the plastics field. The largest group is in the 16 to 25 years experience at 40.7 percent.

Number of Years Experience	**Number Responding**	**Percent**
Less than 5	0	0
6 to 10	5	18.6
11 to 15	7	25.9

Continue

Table 4.6: Years Experience in the Field of Plastics Manufacturing

Table 4.6 continued

Number of Years Experience	**Number Responding**	**Percent**
16 to 25	11	40.7
26 to 30	1	3.7
Greater than 30	3	11.1
Total	**27**	**100**

In comparing years of plastics practitioner experience between the DACUM expert panel and the responders the researcher found the following. The DACUM panel members averaged 24.8 years, while the responders averaged 18 years experience. Thus the DACUM panel members had more years experience.

The data in Table 4.7 provide information relative to the level of education completed by the respondents. All respondents had at least a high school education and 40.7 percent of the respondents indicated post secondary training.

Education	Number	Percent
High school	9	33.3
Vocational school	2	7.5
Apprenticeship	5	18.5
Associate degree	6	22.2
Bachelor degree	5	18.5
Masters degree	0	0
Other (Please specify)	0	0
Total	**27**	**100**

Table 4.7: Level of Education

Task and Enabler Analysis

Data cutoff points are needed in determining the tasks to be taught for curriculum improvement. The initial cutoff points used in this study are based on guidelines from the competency-based systematic curriculum and instructional development model called, “Systematic Curriculum and Instructional Development” (Norton, 2007). The following plastics technologist tasks and enablers cutoff points will serve only as a starting point when deciding what to select for skills (tasks and enablers) training. After this study the SCC OPT faculty and the Advisory Curriculum

Steering Committee will evaluate the tasks and enablers from this study for their integration into the plastics curriculum. Other closely related manufacturing and business courses could also address these enablers. For this study the means, percentages, and criticality numbers above the cutoff point will be considered as important for curriculum development (see Table 4.8).

Research Question/Enablers/Criticality	Cutoff Point
First research question, "What are the duties and tasks that manufacturing employers need for a manufacturing plastics technologist to perform?"	Developed by DACUM panel
Second research question, "What are the entry level tasks as indicated by a census of manufacturing plastics technologists?"	The percentage above 33.0
Third research question, "How do manufacturing plastics technologists rate the tasks on: A) **importance to the job** and B) **difficulty to perform**?"	The mean above 2.500 for both questions
Enablers	The mean above 2.500
Criticality	9.0 and above

Table 4.8: Analysis Cutoff Points

Research Questions

The **first research question**, "What are the duties and tasks that manufacturing employers need for a manufacturing plastics technologist to perform?" The following procedures were used:

- The DACUM workshop with an expert panel was conducted to identify the duties and tasks performed by industrial plastics technologist.

The DACUM process seeks to evaluate an occupation by looking at the whole job, which is then broken down into distinct duties and where each duty has tasks. Figure 4.1 is a graphic representation of an occupation and how the DACUM process with an expert panel establishes relationships between the job and its duties and tasks. The whole job being studied is the occupation of a plastics technologist. The DACUM workshop found 11 duties, 78 tasks, and 73 enablers for the occupation of plastics technologist.

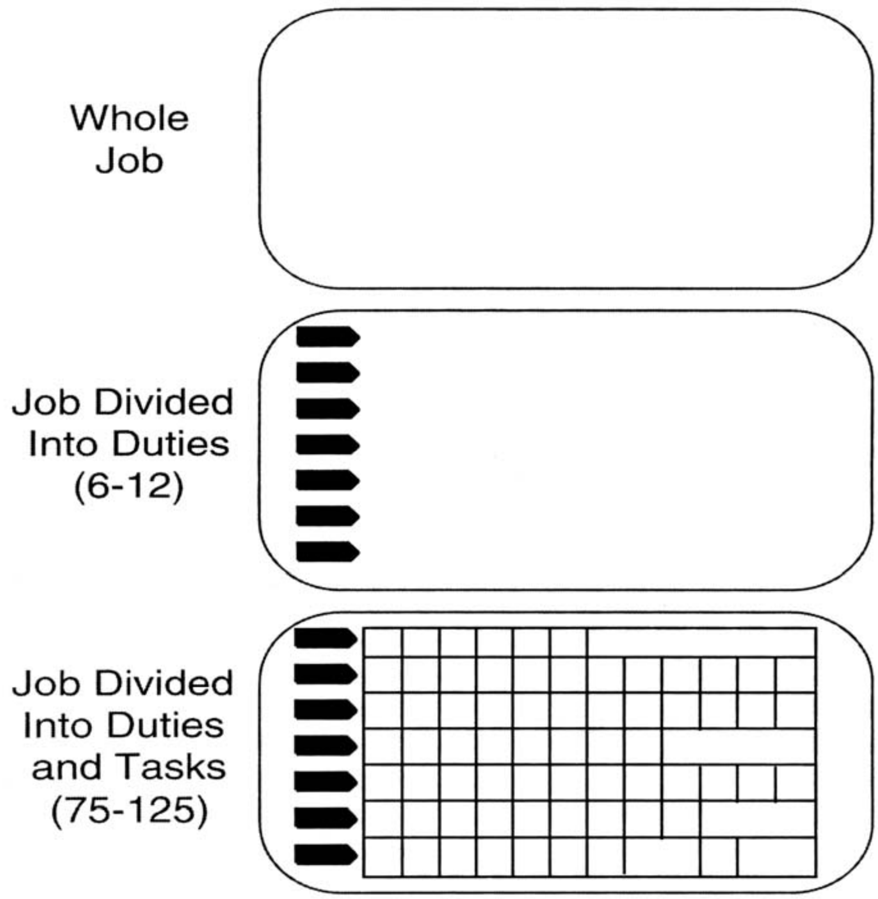

Figure 4.1: Job, Duty and Task Relationships

Figure by: (Norton, 1997)

DACUM Research Chart for Industrial Plastics Technologist

DACUM Panel

Bill Bradley
Plastics Engineer
Plasco, Inc.

Daniel Brothers
Plastics Technician
Industrial Fiberglass Specialties

Dennis Cella
Plastics Technician
Ashton Plastic Products, Inc.

Sandy Feola
Plastics Quality Engineer
Plastic Trim

Robert Hazel
Plastics Practitioner
National Composite Center

Bob Rajkovich
Plastics Engineer
Granger Plastics

Jorge Revillas
Plastics Engineer
Creative Extruded Product

Ron Uhls
Plastics Technician
Encon

DACUM Facilitator
David G. Meyer
Sinclair Community College

DACUM Recorder
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Operations Technology Dept.
Manufacturing Engineering Technology
444 West Third Street
Dayton, Ohio 45402-1460

Date January 4 &5, 2008

Continued

Figure 4.2: DACUM Research Chart

Figure 4.2 continued

DACUM Research Chart for Industrial Plastics Technologist

	Duties	Tasks				
A	Support Administration Goals	A-1 Obtain company vision & goal statement	A-2 Review goals of management	A-3 Review resources for goals	A-4 Review budget for goals	A-5 Review timeline for goals
B	Implement Processing Principles and Techniques	B-1 Determine raw material requirements	B-2 Determine temperature and time requirement	B-3 Determine pressure requirements	B-4 Define melt viscosity	B-5 Evaluate dryness of material, % moisture
C	Install tooling and material	C-1 Define plastic mfg. process	C-2 Review raw material selection criteria	C-3 Select appropriate mold and tooling	C-4 Determine tooling/mold installation procedures	C-5 Review process line layout
D	Maintain Production Processes	D-1 Determine customer specifications	D-2 Implement process parameters	D-3 Monitor process controls	D-4 Analyze process data	D-5 Troubleshoot process parameters
E	Provide Manufacturing Related Training	E-1 Identify training needs	E-2 Create training package	E-3 Schedule employee training	E-4 Conduct employee training	E-5 Evaluate Training feedback
F	Verify Quality Testing	F-1 Perform technical tests	F-2 Analyze results of tests	F-3 Document test results	F-4 Identify manufacturing problem	F-5 Determine solution to problem
G	Arrange Logistics of Stock Keeping Units	G-1 Procure SKU Bill of Material	G-2 Verify correct product SKU (beginning line clearance)	G-3 Identify presence of starter material	G-4 Confirm starter material located at work center	G-5 Verify correct SKU (end line clearance)
H	Maintain Equipment	H-1 Monitor preventative maintenance schedule	H-2 Maintain equipment periodic maintenance	H-3 Maintain preventative maintenance schedule	H-4 Maintain daily housecleaning schedule	H-5 Analyze effectiveness of maintenance
I	Improve Manufacturing Processes	I-1 Evaluate mfg. process needs	I-2 Gather improvement ideas	I-3 Identify opportunities for automation	I-4 Define improvement cost savings	I-5 Present improvement to management
J	Implement Part Design Procedure	J-1 Determine value eng'r cost trade-offs in part design	J-2 Identify parts service life base on environment	J-3 Identify part design characteristic	J-4 Identify material thickness criteria	J-5 Determine material & process relation
K	Maintain Personal Development	K-1 Create personal development plan	K-2 Present personal development plan to mgt.	K-3 Complete annual OSHA/EPA training	K-4 Participate in mandatory job-related training	K-5 Acquire regulatory certification

Continued

Figure 4.2 continued

Date: January 4 & 5, 2008

A-6 Track budget for goals	A-7 Evaluate project budget goals	A-8 Evaluate completed projects				
B-6 Determine regrind effects on product and process	B-7 Confirm material characteristics	B-8 Evaluate quality of material	B-9 Identify process parameters	B-10 Identify control parameters	B-11 Document process parameters	B-12 Participate in process failure mode effects analysis
C-6 Document process parameters						
E-6 Provide documentation for training received						
F-6 Provide results to customer or agency	F-7 Implement manufacturing changes	F-8 Evaluate manufacturing effectiveness of changes	F-9 Document manufacturing changes and results			
I-6 Prepare facility action plan	I-7 Initiate improvement project	I-8 Prepare facility drawings	I-9 Assist in installing improvement equipment	I-10 Provide training on improved equipment		
K-6 Attend professional meetings for new technology	K-7 Read industrial publications for new technology					

Continued

Figure 4.2: continued

General Knowledge and Skills

Communication (oral & written)
Troubleshooting
Coaching
Mentoring
Math
Analytical
Planning
Spreadsheets
CAD (AutoCAD, Solid Works, Inventor)
Knowledge of thermodynamics
Mechanical applications
Multi-tasking
Blue print reading
Six sigma
Basic accounting
ISO standards
Lean manufacturing
Knowledge of safety
Procedure writing (work instructions)
Organizational skills
Value engineering
FEMA for process
FEMA for design
Bar coding

Tools, Equipment, Supplies and Materials

Safety equipment
Hand tools
Analysis tools
Inspection tools
Environment equipment
Telephone/voice mail
Cell phone

Acronyms

FMEA – Failure mode effect analysis
SKU – Stock Keeping Unit
OSHA – Occupational Safety and Health Administration (Safety)
EPA – Environmental Protection Agency
Eng'r - Engineering

Worker Behaviors

Able to accept constructive criticism
Cooperative
Confident
Ability to interact with professionals/managers/customers
Drives for consensus
Decisive
Honest
Positive attitude
Dependable
Assertive
Efficient
Patient
Sense of humor
Safety conscious
Quick learner
Trustworthy
Non-smoker
Enthusiastic
Innovative
Team player
Self-starter
Goal oriented
Detail oriented
Good listener
Integrity
Work ethic

Future Trends and Concerns

Empowerment of employees
Nanotechnology
Theory of constraints
Outdated equipment
Experience gap in workforce
Lack of shop capacity for impact product
Lower volume lots
Quick changeover
Outsourcing
Increased production
Lack of training program for hourly employees
Increased safety culture
High employee turn-over
Supply chain management
Electric machines becoming more popular
Value-added production

The outcome of the DACUM process was the development of the research chart (see Figure 4.2) with duties and tasks. These duties and tasks came from the DACUM expert panel with a focus on the occupation of plastics technologists. This research chart provided direction for establishing the task verification survey (see Appendix L). Thus the first question is answered with the duties and tasks determined by the DACUM workshop.

The **second research question**, “What are the entry level tasks as indicated by a consensus of manufacturing plastics technologists?” These tasks were analyzed in terms of percent of entry level technologists who perform each task. These tasks are ranked in descending order (see Table 4.10). The higher the percentage ranking indicates the greater importance that task is for entry level plastic technologists to perform. The cutoff point was set above 33 percent. In the data the first task had 26 of 27 who agreed with a “yes” to the task with one person answering “no.” The last task, “schedule employee training” had three who answered “yes” or 11 percent. This task could be the responsibility of higher level plastic technologists or management personnel.

(N = number answering “YES”)	**N**	**Percentage**
1. Participate in mandatory job-related training	26	96.3
2. Document process parameters	26	96.3
3. Troubleshoot process parameters	25	92.6
4. Participate in process failure mode effects analysis	25	92.6
5. Gather improvement ideas	24	88.9
6. Monitor process controls	24	88.9
7. Implement process parameters	24	88.9
8. Identify control parameters	24	88.9
9. Determine raw material requirements	24	88.9
10. Identify manufacturing problem	24	88.9
11. Confirm material characteristics	23	85.2
12. Determine regrind effects on product and process	23	85.2
13. Document process parameters	23	85.2
14. Identify control parameters	23	85.2
15. Determine temperature and time requirement	23	85.2
16. Present improvement to management	22	81.5
17. Determine solution to problem	22	81.5
18. Evaluate quality of material	22	81.5
19. Read industrial publications for new technology	22	81.5
20. Obtain company vision & goal statement	22	81.5
21. Analyze process data	21	77.8
22. Evaluate mfg. process needs	21	77.8
23. Perform technical tests	21	77.8
24. Document test results	20	74.1
25. Implement manufacturing changes	20	74.1
26. Determine tooling/mold installation procedures	20	74.1
27. Define plastic manufacturing process	20	74.1
28. Review goals of management	20	74.1
29. Evaluate dryness of material, % moisture	20	74.1
30. Determine pressure requirements	19	70.4
31. Maintain daily housecleaning schedule	19	70.4
32. Document manufacturing changes and results	19	70.4
33. Evaluate manufacturing effectiveness of changes	19	70.4

Continued

Table 4.9: Entry Level Tasks Percentage

Table 4.9 continued

(N = number answering "YES")	**N**	**Percentage**
34. Confirm starter material located at work center	19	70.4
35. Determine customer specifications	18	66.7
36. Maintain equipment periodic maintenance	17	63.0
37. Select appropriate mold and tooling	17	63.0
38. Attend professional meetings for new technology	17	63.0
39. Determine material & process relation	17	63.0
40. Define improvement cost savings	17	63.0
41. Identify opportunities for automation	17	63.0
42. Review process line layout	17	63.0
43. Review raw material selection criteria	17	63.0
44. Provide training on improved equipment	17	63.0
45. Identify presence of starter material	17	63.0
46. Review timeline for goals	17	63.0
47. Complete annual OSHA/EPA training	16	59.3
48. Evaluate completed projects	16	59.3
49. Evaluate training feedback	16	59.3
50. Conduct employee training	16	59.3
51. Review resources for goals	16	59.3
52. Analyze effectiveness of maintenance	15	55.6
53. Analyze results of tests	15	55.6
54. Monitor preventative maintenance schedule	14	51.9
55. Assisting installing improvement equipment	14	51.9
56. Provide documentation for training received	14	51.9
57. Define melt viscosity	14	51.9
58. Verify correct SKU (end line clearance)	13	48.1
59. Initiate improvement project	13	48.1
60. Maintain preventative maintenance schedule	13	48.1
61. Acquire regulatory certification	12	44.4
62. Identify training needs	11	40.7
63. Create personal development plan	10	37.0
64. Present personal development plan to management	10	37.0
65. Identify material thickness criteria	9	33.3
66. Verify correct product SKU (beginning line clearance)	9	33.3

Continued

Table 4.9 continued

(N = number answering "YES")	**N**	**Percentage**
67. Identify part design characteristic	9	33.3
68. Provide results to customer or agency	8	29.6
69. Prepare facility action plan	7	25.9
70. Determine value cost trade-offs in part design	7	25.9
71. Prepare facility drawings	6	22.2
72. Procure SKU (stock keeping unit) bill of material	6	22.2
73. Create training package	6	22.2
74. Identify parts service life base on environment	5	18.5
75. Track budget for goals	5	18.5
76. Evaluate project budget goals	5	18.5
77. Review budget for goals	4	14.8
78. Schedule employee training	3	11.1

The percentage cutoff point for entry level tasks is 33.3. At the 33.3 percent level 85 percent of the tasks were above the cutoff point. With the entry level tasks ranked in descending order data research question two has been answered.

The **third research question** has two parts. "How do manufacturing plastics technologists rate the tasks on: A) **importance to the job** and B) **difficulty to perform**?" In this question the means of task "importance to the job" and "difficulty to perform" are analyzed separately. The importance to the job and difficulty of performing each task were both rank ordered based on their means to determine their importance in this study. The tasks were listed in descending order while the researcher focused only on the tasks with means at the cutoff of 2.500 and above. The means cutoff point at 2.500 was set for both sets of tables. The low mean for task "importance to the job" is 2.889 and task "difficulty to perform" is 1.704. Each set of data was analyzed using Tables 4.10 and 4.11 and visually using a scatter plot (see Table 4.13).

In Table 4.13, the task importance means to the job and task difficulty means to perform are presented in quadrants of a scatter plot, to visually see the tasks association with each other. Each mean of task importance is represented by a point so that the horizontal position corresponds to the mean of task difficulty. Each point has a different mark on the scatter plot that matches the scatter plot schedule. The quadrants are marked, I -"Task is Extremely Difficult, but Not Important," II - "Task is Extremely Difficult and Extremely Important," III - "Task is Extremely Easy, but Not Important," and IV - "Task is Extremely Easy and Extremely Important." The four quadrants were established using half the range of the 0 to 5 Likert scale or 2.500. A composite scatter plot of all 78 tasks is found in Table 4.13, followed by 11 separate scatter plots of each duty. Duty A has 8 tasks and in the scatter plot marked "Duty A" the schedule lists Da.1 for Duty A – task 1, etc. A complete listing of all duties and tasks may be found in Appendix L (Task Verification Survey).

	Mean	**Standard Deviation**
1. Determine solution to problem	4.519	1.122
2. Define improvement cost savings	4.407	1.118
3. Implement manufacturing changes	4.296	0.912
4. Evaluate manufacturing effectiveness of changes	4.259	0.903
5. Determine customer specification	4.259	1.163
6. Review timeline for goals	4.259	0.859
7. Identify manufacturing problem	4.259	1.130
8. Evaluate quality of material	4.259	1.375
9. Define plastic mfg. process	4.222	1.121
10. Identify control of parameters	4.222	1.013
11. Select appropriate mold and tooling	4.185	1.145
12. Evaluate completed projects	4.185	1.145
13. Present improvement to management	4.185	0.834
14. Gather improvement ideas	4.185	0.879
15. Troubleshoot process parameters	4.148	1.292
16. Analyze process data	4.148	0.949
17. Document process parameters	4.148	1.134
18. Obtain company vision & goal statement	4.111	1.311
19. Monitor process controls	4.111	1.281
20. Identify process parameters	4.074	1.072
21. Implement process parameters	4.074	1.269
22. Document process parameters	4.074	1.072
23. Participate in mandatory job-related training	4.037	1.344
24. Evaluate mfg. process needs	4.037	0.808
25. Evaluate project budget goals	4.037	0.898
26. Review budget for goals	4.000	0.800
27. Participate in process failure mode effects analysts	3.963	1.192
28. Prepare facility action plan	3.963	0.898
29. Determine tooling/mold installation procedures	3.926	1.107
30. Review goals of management	3.926	1.240
31. Analyze effectiveness of maintenance	3.889	1.280
32. Conduct employee training	3.852	1.033

Continued

Table 4.10: Task Importance Means

Table 4.10 continued

	Mean	**Standard Deviation**
33. Confirm material characteristics	3.852	1.130
34. Identify opportunities for automation	3.815	0.920
35. Determine raw material requirements	3.815	1.360
36. Identity training needs	3.815	1.270
37. Review process line layout	3.815	1.080
38. Document manufacturing changes and results	3.778	1.552
39. Determine temperature and time requirement	3.778	1.340
40. Review resources for goals	3.778	1.010
41. Evaluate training feedback	3.741	0.981
42. Determine pressure requirements	3.741	1.530
43. Provide results to customer or agency	3.741	1.350
44. Evaluate dryness of material, % moisture	3.704	1.489
45. Monitor preventative maintenance schedule	3.704	1.436
46. Track budget for goals	3.667	1.144
47. Review raw material selection criteria	3.667	1.732
48. Determine regrind effects on product and process	3.667	1.109
49. Initiate improvement project	3.667	1.000
50. Verify correct SKU (end line clearance)	3.630	1.445
51. Identify material thickness criteria	3.593	1.600
52. Maintain preventative maintenance schedule	3.593	1.716
53. Define melt viscosity	3.593	1.421
54. Provide training on improved equipment	3.593	1.338
55. Perform technical tests	3.556	1.450
56. Determine material & process relation	3.481	1.369
57. Identify part design characteristic	3.481	1.553
58. Maintain equipment periodic maintenance	3.481	1.602
59. Confirm starter material located at work center	3.444	1.577
60. Identify presence of starter material	3.444	1.553
61. Verify correct product SKU (beginning line clearance)	3.407	1.338
62. Analyze results of tests	3.407	1.500
63. Read industrial publications for new technology	3.407	1.185
64. Maintain daily housecleaning schedule	3.370	1.363
65. Complete annual OSHA/EPA training	3.370	1.621

Continued

Table 4.10 continued

	Mean	**Standard Deviation**
66. Determine value engineering coast trade-offs in part design	3.333	1.441
67. Document test results	3.296	1.514
68. Create personal development plan	3.259	1.259
69. Provide documentation for training received	3.259	1.259
70. Acquire regulatory certification	3.259	1.583
71. Present personal development plan to mgt.	3.222	1.396
72. Attend professional meetings for new technology	3.148	1.322
73. Create training package	3.148	1.027
74. Schedule employee training	3.074	1.412
75. Prepare facility drawings	3.037	1.698
76. Procure SKU (stock keeping units) bill of material	3.037	1.372
77. Identify parts service life based on environment	3.000	1.544
78. Assist in installing improvement equipment	2.889	1.188

The order of task difficulty to perform responses changed in comparison to task importance to the job. However, both tables show importance and difficulty pertaining to some of the tasks. In Tables 4.10 and 4.11 the first three tasks include the following two tasks, "Define improvement cost saving" and "Determine solution to problem."

	Mean	**Standard Deviation**
1. Determine value engineering cost trade-offs in part design	3.629	1.148
2. Define improvement cost savings	3.593	1.118
3. Determine solution to problem	3.556	1.476

Continued

Table 4.11: Task Difficulty Means

Table 4.11 continued

	Mean	**Standard Deviation**
4. Troubleshoot process parameters	3.481	1.221
5. Identify opportunities for automation	3.481	0.935
6. Identify manufacturing problems	3.444	1.219
7. Create training package	3.444	1.155
8. Confirm material characteristics	3.407	0.797
9. Identify part design characteristic	3.370	0.967
10. Evaluate project budget goals	3.333	1.000
11. Determine material & process relation	3.333	1.000
12. Evaluate quality of material	3.296	0.912
13. Initiate improvement project	3.259	0.903
14. Identify parts service life base on environment	3.259	1.059
15. Evaluate manufacturing effectiveness of changes	3.259	1.023
16. Analyze process data	3.259	1.196
17. Evaluate mfg. process needs	3.185	1.001
18. Identify material thickness criteria	3.148	1.064
19. Analyze effectiveness of maintenance	3.148	1.610
20. Participate in process failure mode effect analysis	3.148	1.027
21. Determine customer specifications	3.111	1.188
22. Identify training needs	3.111	1.188
23. Prepare facility action plan	3.111	1.086
24. Present improvement to management	3.074	0.730
25. Track budget for goals	3.074	1.174
26. Implement process parameters	3.074	0.917
27. Gather improvement ideas	3.074	0.781
28. Evaluate completed projects	3.074	0.829
29. Maintain preventative maintenance schedule	3.037	1.850
30. Evaluate training feedback	3.037	0.980
31. Schedule employee training	3.000	1.209
32. Verify correct product SKU (beginning line clearance)	3.000	1.271
33. Implement manufacturing changes	2.963	1.400
34. Review budget for goals	2.963	0.940

Continued

Table 4.11 continued

	Mean	**Standard Deviation**
35. Prepare facility drawings	2.963	1.506
36. Define melt viscosity	2.963	1.454
37. Define plastic mfg. process	2.963	1.126
38. Review timeline for goals	2.926	0.829
39. Provide training on improved equipment	2.889	1.121
40. Analyze results of tests	2.852	1.134
41. Identify process parameters	2.852	1.167
42. Identify control parameters	2.815	1.001
43. Present personal development plan to mgt.	2.815	1.241
44. Provide results to customer or agency	2.815	1.331
45. Document process parameters	2.778	1.188
46. Determine tolling/mold and installation procedures	2.741	0.859
47. Review raw material selection criteria	2.741	1.059
48. Monitor preventative maintenance schedule	2.741	1.483
49. Perform technical tests	2.704	1.171
50. Conduct employee training	2.704	0.953
51. Maintain equipment periodic maintenance	2.667	1.617
52. Monitor process controls	2.667	1.109
53. Determine regrind effects on product and process	2.667	1.109
54. Create personal development plan	2.630	1.445
55. Document manufacturing changes and results	2.630	1.115
56. Acquire regulatory certification	2.630	1.391
57. Assist in installing improvement equipment	2.630	0.839
58. Determine raw material requirements	2.630	1.214
59. Verify correct SKU (end line clearance)	2.593	1.185
60. Review process line layout	2.593	1.366
61. Procure SKU (stock keeping unit) bill of material	2.556	1.050
62. Evaluate dryness of material, % moisture	2.444	1.396
63. Select appropriate mold and tooling	2.444	1.368
64. Determine pressure requirements	2.444	1.121
65. Complete annual OSHA/EPA training	2.407	1.394

Continued

Table 4.11 continued

	Mean	**Standard Deviation**
66. Document test results	2.407	1.047
67. Attend professional meetings for new technology	2.370	1.523
68. Determine temperature and time requirement	2.370	0.884
69. Review resources for goals	2.370	0.926
70. Read industrial publications for new technology	2.259	1.678
71. Confirm starter material located at work center	2.185	1.111
72. Provide documentation for training received	2.185	0.921
73. Document process parameters	2.148	0.864
74. Identify presence of starter material	2.074	1.357
75. Review goals of management	2.000	1.038
76. Participate in mandatory job-related training	1.889	1.155
77. Obtain company vision & goal statement	1.852	1.379
78. Maintain daily housecleaning schedule	1.704	0.953

In the scatter plots most mean task associations were found to cluster in quadrant II, while some were in IV. The quadrants of II - “Task is Extremely Difficult and Extremely Important” and IV - “Task is Extremely Easy and Extremely Important” contain these tasks. No tasks appeared in quadrants I and III. In Table 4.12 the percentage differences for number of tasks in quadrants is significant comparing 84.6 percent (II) to 15.4 percent (IV). Four duties out of eleven (36.4 percent) had zero tasks in quadrant IV. In every case in quadrant II, the number of task points exceeded that of quadrant IV. The best means association is Duty F – 5 (Determine solution to problem), while the poorest means association is Duty H - 5 (Analyze effectiveness of maintenance). All of the associated means in both quadrants (II and IV) are above the mean of 2.5

which is the cutoff point mean based on the Likert scale used. This indicates all these tasks are important to plastics technologists. The researcher will use all the data from research question number three and will evaluate how much class time is available to assist in deciding which tasks will be taught. The tasks which are extremely difficult and extremely important could consume more class time than is available. If this is the case, an additional course with a focused curriculum could have merit.

Duty	**Quadrant II**	**Quadrant IV**
A	5	3
B	10	2
C	4	2
D	5	0
E	5	1
F	8	1
G	3	2
H	4	1
I	10	0
J	5	0
K	7	0
Total	**66 or 84.6 Percent**	**12 or 15.4 Percent**

Table 4.12: Scatter Plot Quadrant Comparison

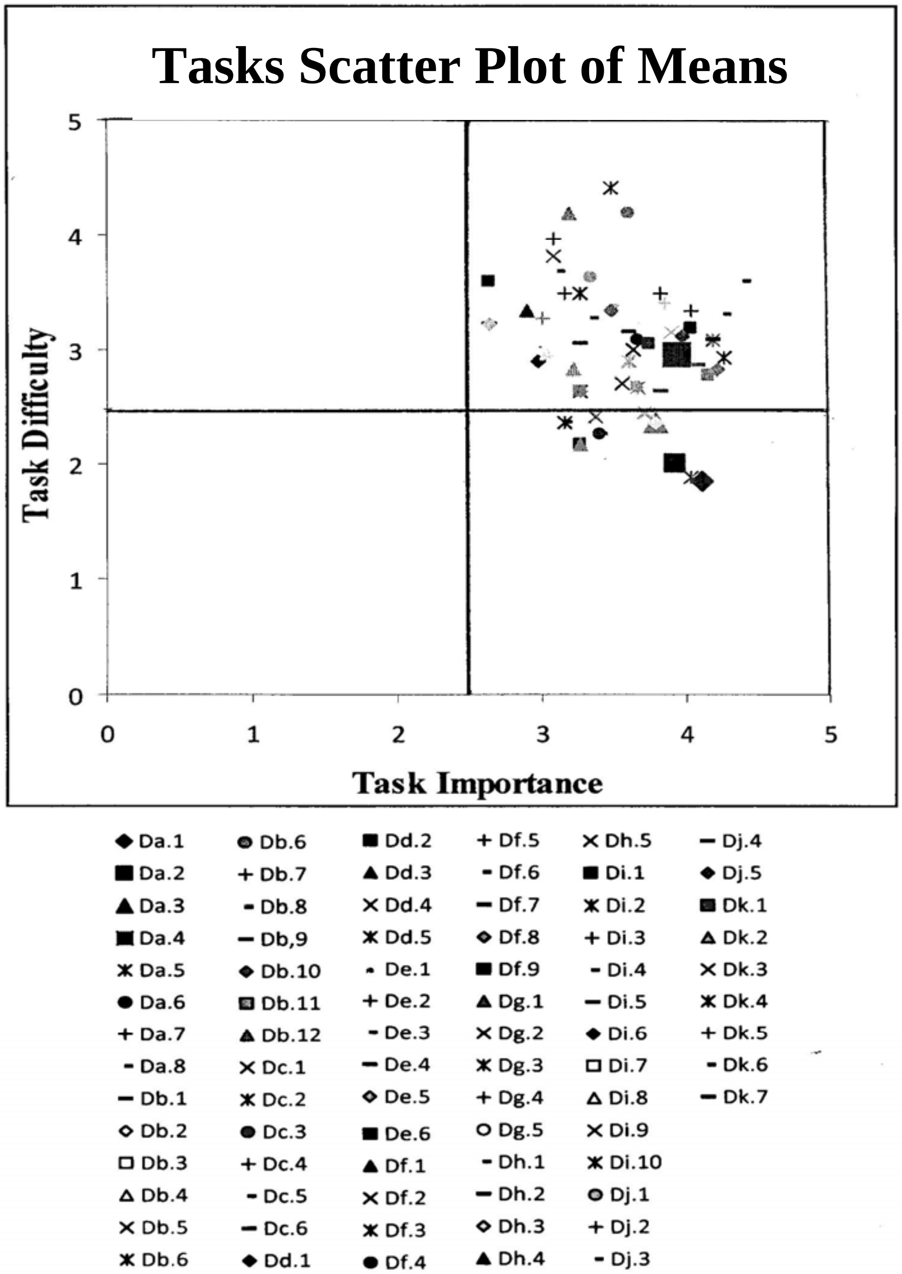

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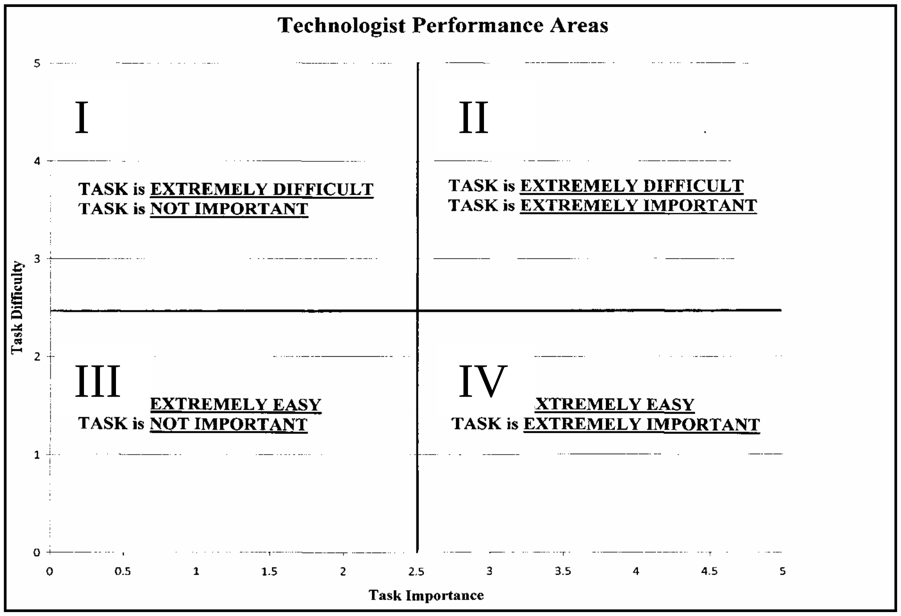
Table 4.13: Task and Difficulty Means Scatter Plot

Table 4.13 continued



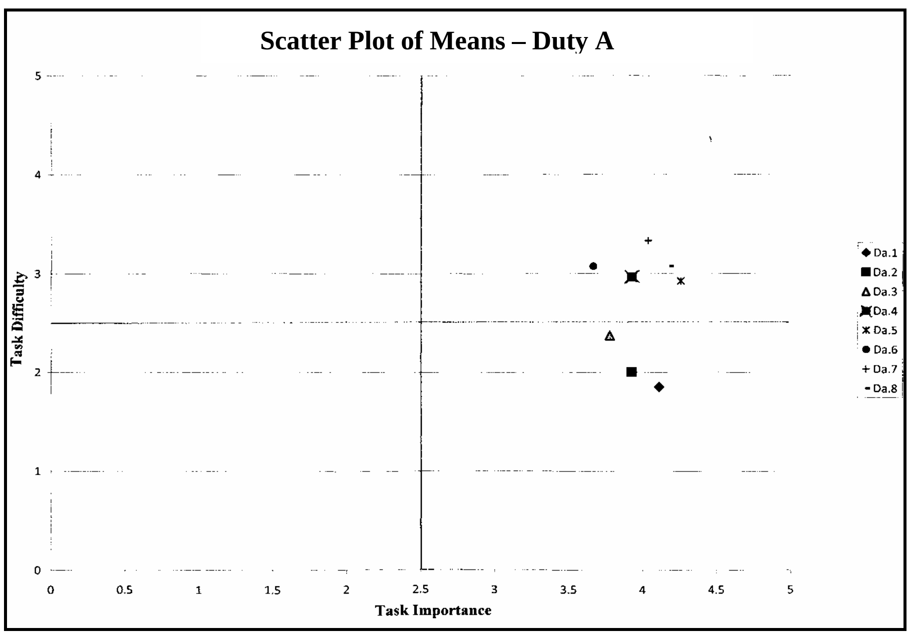


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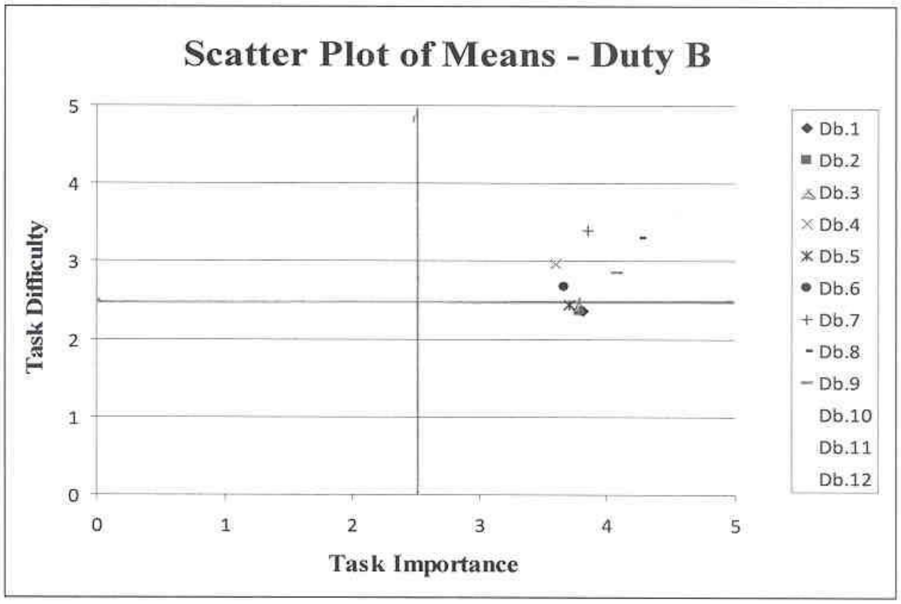
Table 4.13 continued



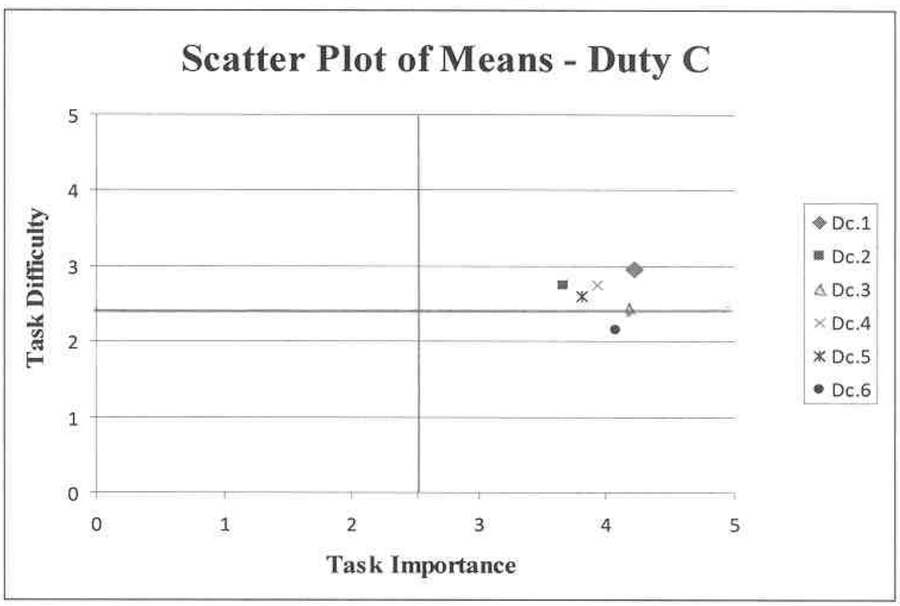


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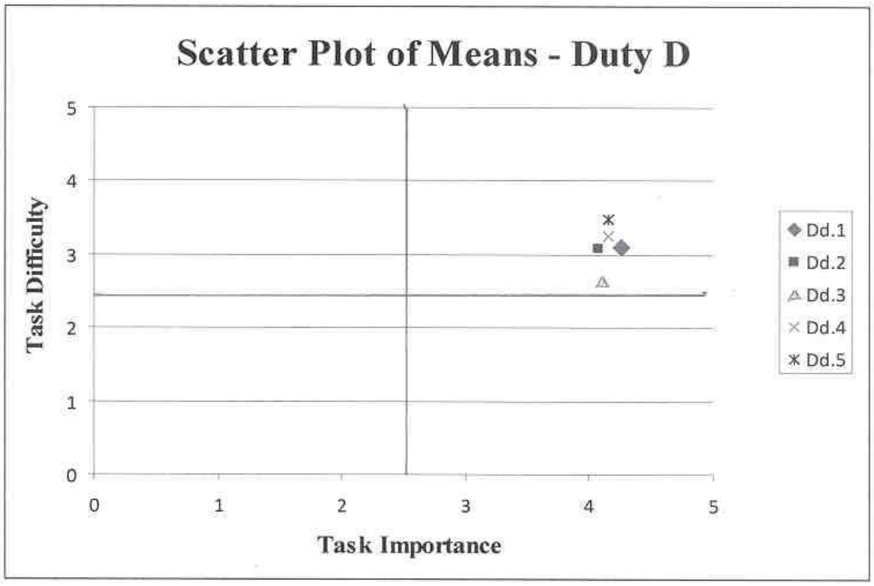
Table 4.13 continued



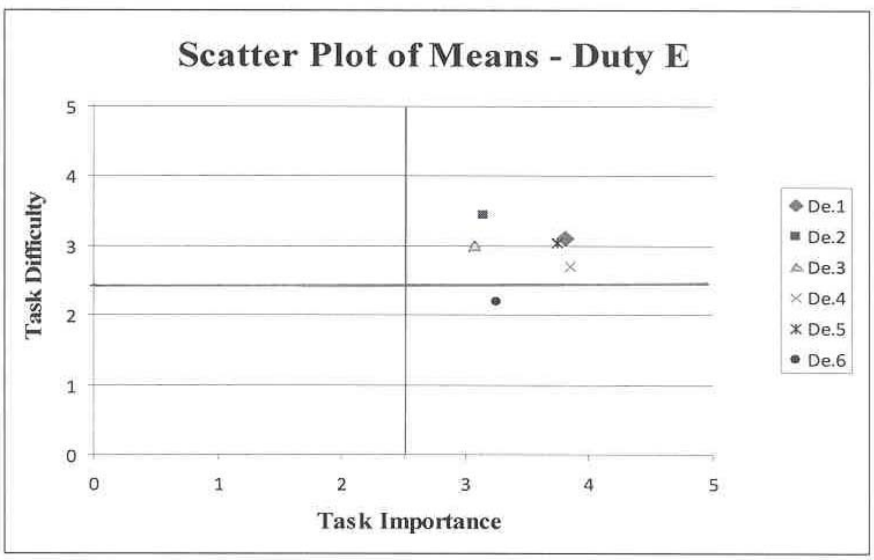


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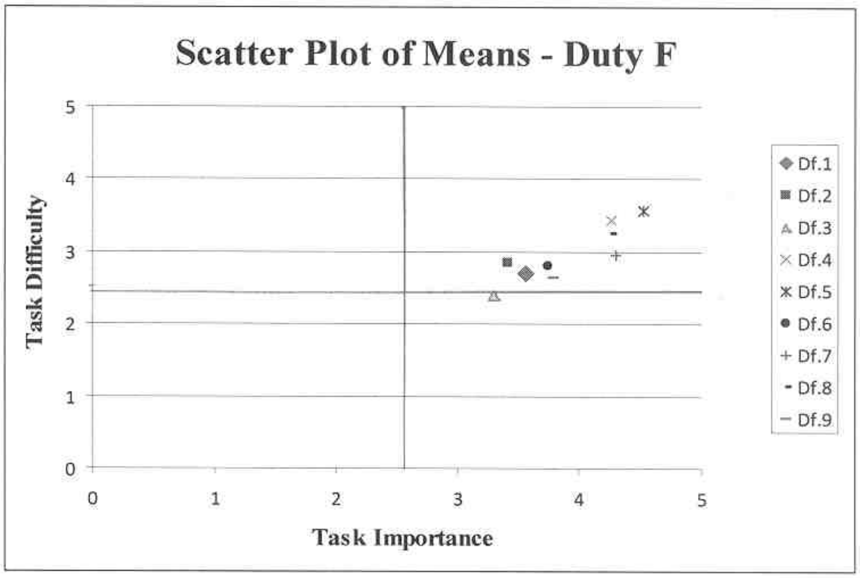
Table 4.13 continued



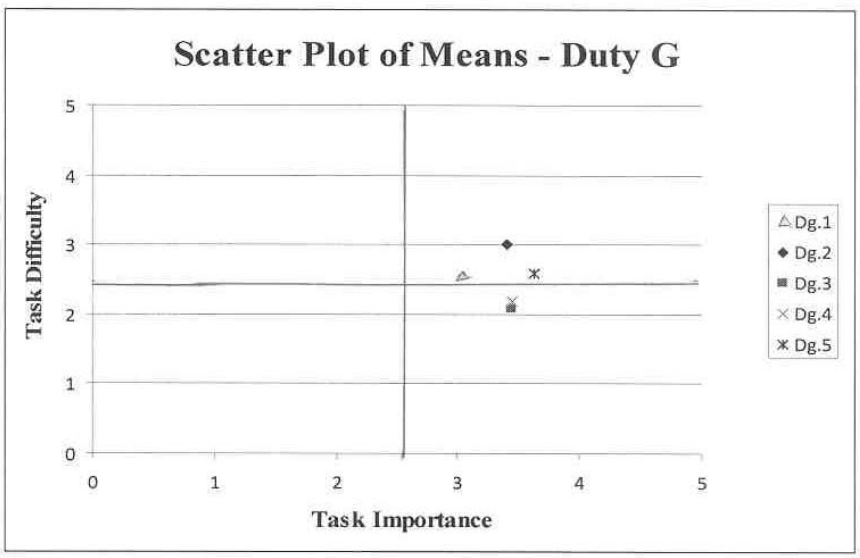


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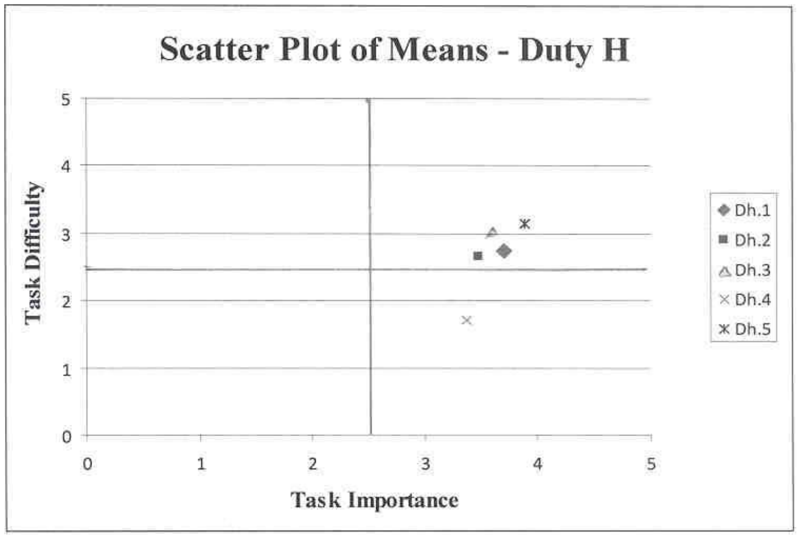
Table 4.13 continued



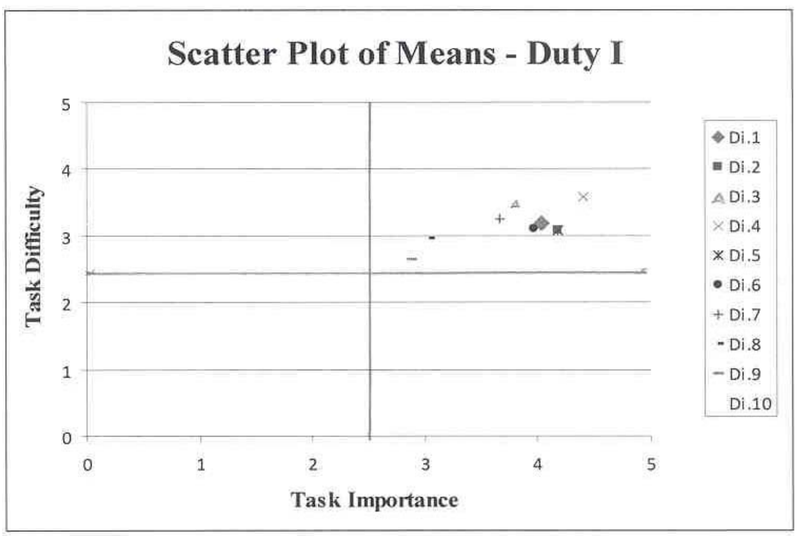


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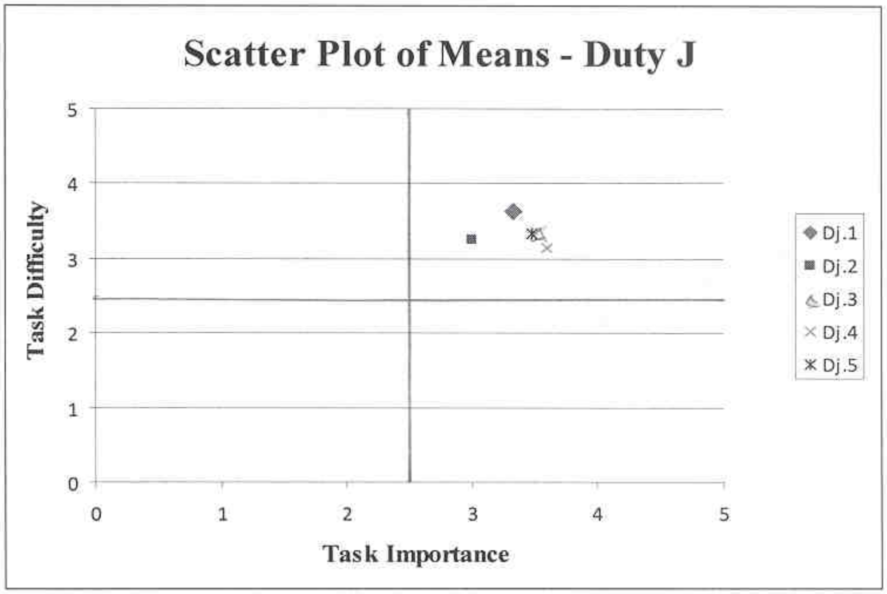
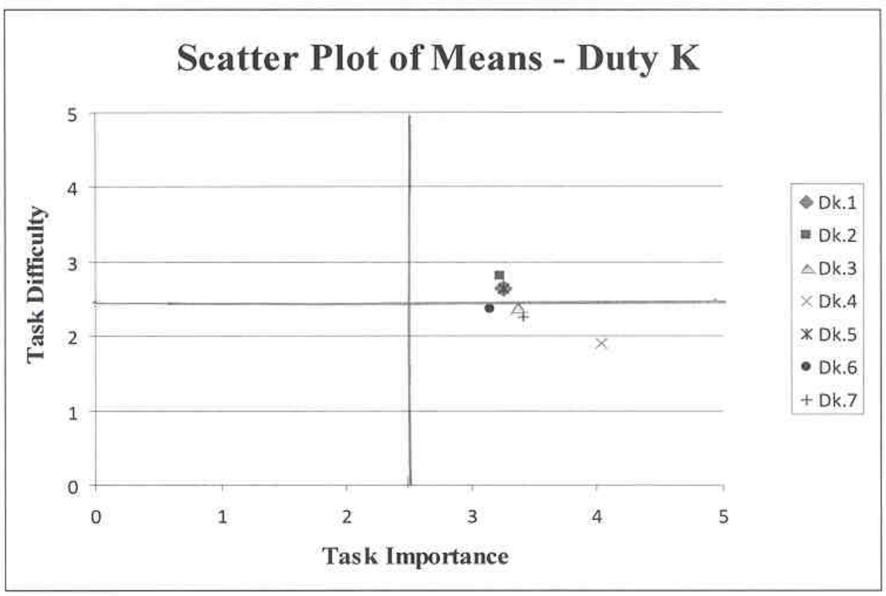
Table 4.13 continued





Enablers

Enablers are important in any occupation and are topics that are content based or could be a personality trait. Not all enablers are required of an individual to be a successful plastics technologist. Rather the enabler list, developed by the DACUM panel, provides available subjects or behaviors that the technologists could pursue to further develop themselves and benefit their employer. In the classroom enablers are secondary subjects generally integrated into the curriculum (teaming, communication skills, good listener, etc.). The personality trait enablers are not specifically taught, but are made known to students and acquired through interaction with parents, other students, and in the workplace, whereas the content enablers are usually taught in a classroom setting and are also monitored during instruction.

In Table 4.15 the higher means ranking of enablers indicate the degree to which each enabler, based on the responder's selection, is critical to on the job performance of plastics technologists. The researcher arbitrarily set the mean cutoff above 2.5 as being important. The enablers above 2.500 will be given more consideration as topics to teach.

Frequency was gathered to assess the distribution of responses. Based on the frequency data enabler number 27 (Innovation), the mean was 4.111 (see Table 4.15) where visual change in frequency distribution started to take place. Here "innovation" was scored as "not critical" and this was the point where responders started scoring higher frequencies of "not critical." The researcher analyzed the responses and found differences between two groups of responders. The analyzed groups were in the area of education levels of responders (see Table 4.7). Group one was high school through apprenticeship (designated HS) and group two started with associate through bachelors (designated BS) degrees. HS had 16 members while BS had 11. The findings were that HS and BS had means close to each other starting with enabler number 1 through 26. Based on data from Table 4.14, BS's means in comparison to HS's means started to diverge with the first response of "not critical -0" for enabler number 27 (Innovative).

A convenience sample of six enablers (see Table 4.14) was chosen below the mean of 4.111 in Table 4.15. The enablers: lean manufacturing, supply chain management, failure mode effects analysis (design), bar coding, basic accounting, and six sigma were arbitrarily chosen. In analyzing data in Tables 4.14 and 4.15, it appeared that HS had means that were lower in comparison to BS. A 72 percent increase in grand means is the results of comparing the grand means of HS to BS. This small sample of enablers lacks larger sample sizes, but suggests further study. Past SME (1999) studies indicate that manufacturers need technologists capable of process improvement, one who understands new technology, and has cost saving skills, which higher education provides for enablers in Table 4.14.

Enabler	**Table 4.14 Means**	**H S Means**	**B S Means**
# 44 Lean Manufacturing	3.667	3.000	4.636
# 55 Supply Chain Mgt.	3.259	3.000	4.272
# 62 Failure Mode Effects Analysis (Design)	3.000	2.313	4.000
# 67 Bar Coding	2.815	2.000	4.000
# 68 Basic Accounting	2.815	2.000	4.000
# 69 Six Sigma	2.704	1.938	3.720
Grand Means	**3.043**	**2.375**	**4.105**

Table 4.14: Comparing Enablers and Education

	0 - Not Critical	1	2	3	4	5 - Extremely Critical	Mean	Standard Deviation
1. Work ethic	0	0	0	0	3	24	4.888	0.321
2. Dependable	0	0	0	0	3	24	4.888	0.321
3. Safety conscious	0	0	0	0	6	21	4.778	0.424
4. Trustworthy	0	0	0	1	4	22	4.778	0.506
5. Knowledge of safety	0	0	0	1	5	21	4.741	0.526
6. Positive attitude	0	0	0	1	6	20	4.704	0.542
7. Ability to interact with professionals	0	0	0	1	7	19	4.667	0.555
8. Honest	0	0	0	0	10	17	4.630	0.492
9. Integrity	0	0	1	0	8	18	4.593	0.694
10. Self-starter	0	0	0	1	9	17	4.593	0.572
11. Detail oriented	0	0	0	0	13	14	4.519	0.509
12. Safety equipment	0	0	0	3	7	17	4.519	0.700
13. Efficient	0	1	1	0	9	16	4.519	0.643
14. Multi-tasking	0	1	0	2	6	18	4.481	0.935
15. Troubleshooting	0	0	1	1	9	16	4.481	0.753
16. Goal oriented	0	0	0	1	13	13	4.444	0.577
17. Value-added production	0	0	0	1	14	12	4.407	0.572
18. Team player	0	0	0	1	14	20	4.407	0.572
19. Quick learner	0	0	0	3	10	14	4.407	0.694
20. Confident	0	0	0	2	14	11	4.333	0.620
21. Cooperative	0	0	0	1	17	9	4.296	0.542
22. Communication (oral & written)	0	1	0	1	15	10	4.296	0.609
23. Good Listener	0	0	0	5	10	12	4.259	0.764
24. Able to accept constructive criticism	0	1	1	0	17	8	4.222	0.577
25. Math	0	0	1	2	15	9	4.185	0.736
26. Analytical	0	0	1	4	12	10	4.148	0.818
27. Innovative	1	0	0	3	13	10	4.111	1.050
28. Decisive	0	0	0	5	15	7	4.074	0.675
29. Patient	0	0	0	8	10	9	4.037	0.808
30. Organizational skills	1	0	0	5	11	10	4.037	1.091
31. Coaching	1	0	0	8	6	12	4.000	1.177
32. Enthusiastic	1	0	0	3	17	6	3.963	0.980
33. Quick changeover	0	0	0	12	4	11	3.963	0.940
34. Lack of training program for employees	0	0	1	6	13	7	3.963	0.808
35. Mentoring	1	0	0	6	12	8	3.926	1.072
36. Assertive	0	0	2	8	8	9	3.889	0.974
37. Empowerment of employees	0	1	1	5	13	7	3.889	0.974
38. Experience gap in workforce	1	0	0	7	13	6	3.815	1.039
39. Mechanical applications	0	1	0	8	13	5	3.778	0.892

Continued

Table 4.15: Enablers Ranked in Mean Descending Order

Table 4.15 continued

(Likert Scale)	**0**	**1**	**2**	**3**	**4**	**5**	**Mean**	**Std Dev**
40. Inspection tools	0	0	3	8	8	8	3.778	1.013
41. Increased production	1	0	2	8	8	8	3.704	1.203
42. Blue print reading	2	0	1	7	8	9	3.704	1.382
43. Increased safety culture	0	3	1	6	9	8	3.667	1.271
44. Lean manufacturing	1	0	3	6	10	7	3.667	1.209
45. Outdated equipment	1	0	6	3	7	10	3.667	1.387
46. Planning	1	0	1	7	15	3	3.630	1.006
47. Value engineering	2	0	1	5	14	5	3.630	1.275
48. Sense of humor	0	0	2	11	10	4	3.593	0.844
49. Drives for consensus	0	2	0	9	12	4	3.593	1.010
50. Procedural writing (work instruction)	1	0	4	5	11	6	3.593	1.217
51. Analysis tools	0	0	4	12	4	7	3.519	1.051
52. Hand tools	0	5	1	5	9	7	3.444	1.423
53. Cell phone	2	0	1	9	11	4	3.444	1.251
54. Knowledge of thermodynamics	2	0	1	10	13	1	3.296	1.137
55. Supply chain management	0	1	6	8	9	3	3.259	1.059
56. Lack of shop capacity impact product	2	0	7	7	5	6	3.148	1.433
57. Lower volume lots	2	0	4	9	11	1	3.111	1.188
58. Failure mode effects analysis (process)	3	0	2	8	14	0	3.111	1.281
59. Environmental equipment	2	0	3	11	11	0	3.074	1.107
60. International Standards Organization	1	4	3	5	12	2	3.074	1.357
61. Spreadsheets	1	0	6	11	8	1	3.037	1.018
62. Failure mode effects analysis (design)	3	0	5	5	14	0	3.000	1.330
63. CAD (Computer Aided Design)	2	0	9	5	7	4	3.000	1.387
64. Telephone/voice mail	3	3	2	5	11	3	3.000	1.569
65. Electric machines are more popular	1	6	3	2	13	2	2.963	1.480
66. Outsourcing	4	0	4	9	7	3	2.889	1.502
67. Bar coding	2	1	8	5	11	0	2.815	1.241
68. Basic accounting	2	3	4	8	9	1	2.815	1.331
69. Six sigma	3	3	1	12	8	0	2.704	1.325
70. Theory of constraints	3	0	10	6	8	0	2.593	1.248
71. High employee turn-over	6	4	3	3	5	6	2.556	1.928
72. Nanotechnology	3	7	6	7	4	0	2.074	1.269
73. Non-smoker	11	3	4	6	1	2	1.593	1.647

1. General Knowledge and Skills	**Mean**	**Std Dev**
1. Communication (oral & written)	4.296	0.609
2. Troubleshooting	4.481	0.753
3. Coaching	4.000	1.176
4. Mentoring	3.926	1.072
5. Math	4.185	0.736
6. Analytical	4.148	0.818
7. Planning	3.629	1.006
8. Spreadsheets	3.037	1.018
9. CAD (Computer Aided Design)	3.000	1.387
10. Knowledge of thermodynamics	3.296	1.137
11. Mechanical applications	3.777	0.892
12. Multi-tasking	4.482	0.935
13. Blue print reading	3.704	1.382
14. Six sigma	2.704	1.325
15. Basic accounting	2.815	1.331
16. ISO (International Standards Organization)	3.074	1.356
17. Lean manufacturing	3.667	1.209
18. Knowledge of safety	4.741	0.526
19. Procedural writing (work instructions)	3.593	1.217
20. Organizational skills	4.037	1.091
21. Value engineering	3.629	1.275
22. FMEA (failure mode and effects analysis) for process	3.111	1.281
23. FMEA (failure mode and effects analysis) for design	3.000	1.330
24. Bar coding	2.815	1.242
2. Worker Behaviors		
1. Able to accept constructive criticism	4.222	0.577
2. Cooperative	4.296	0.542
3. Confident	4.333	0.620
4. Ability to interact with professionals/managers/customers	4.666	0.554
5. Drives for consensus	3.592	1.010
8. Positive attitude	4.704	0.542
9. Dependable	4.889	0.320

Continued

Table 4.16: Enablers Means Ranked by Category

Table 4.16 continued

	Mean	Std Dev
10. Assertive	3.889	0.974
11. Efficient	4.518	0.642
12. Patient	4.037	0.808
13. Sense of humor	3.593	0.844
14. Safety conscious	4.778	0.424
15. Quick learner	4.407	0.694
16. Trustworthy	4.778	0.506
17. Non-smoker	1.593	1.647
18. Enthusiastic	3.963	0.979
19. Innovative	4.111	1.050
20. Team player	4.407	0.573
21. Self-starter	4.593	0.572
22. Goal oriented	4.444	0.577
23. Detail oriented	4.518	0.509
24. Good listener	4.259	0.764
25. Integrity	4.592	0.693
26. Work ethic	4.889	0.320
3. Tools, Equipment, Supplies, & Materials		
1. Safety equipment	4.518	0.700
2. Hand tools	3.444	1.423
3. Analysis tools	3.518	1.051
4. Inspection tools	3.778	1.013
5. Environmental equipment	3.074	1.107
6. Telephone/voice mail	3.000	1.569
7. Cell phone	3.444	1.251

Continued

Table 4.16 continued

4. Future Trends and Concerns	**Mean**	**Std Dev**
1. Empowerment of employees	3.889	0.974
2. Nanotechnology	2.074	1.268
3. Theory of constraints	2.592	1.248
4. Outdated equipment	3.667	1.387
5. Experience gap in workforce	3.815	1.039
6. Lack of shop capacity for impact product	3.148	1.433
7. Lower volume lots	3.111	1.188
8. Quick changeover	3.963	0.939
9. Outsourcing	2.889	1.502
10. Increased production	3.704	1.203
11. Lack of training program for hourly employees	3.963	0.808
12. Increased safety culture	3.667	1.271
13. High employee turn-over	2.556	1.928
14. Supply chain management	3.259	1.059
15. Electric machines becoming more popular	2.963	1.480
16. Value-added production	4.407	0.572

Criticality

The criticality number is composed of the three numbers from each of the tasks scored by each responder (see Appendix U). In the survey three task question areas were scored and they were, 1) “Does an entry level plastics technologists PERFORM this task?” with a “Yes (1) or No (0) response, 2) Task Importance scored from 0 through 5, and 3) Task Difficulty also scored from 0 through 5. All three questions are scored for each task by each respondent. Then all three scores are multiplied together for each respondent. Finally all respondent scores are added and averaged for the criticality number. This combined criticality serves as another measure to compare tasks and duties.

Criticality is ranked in descending order for each duty in Table 4.17. The researcher analyzed only the tasks whose criticality numbers were 9.000 and above. The important duties using the criticality numbers in descending order are: 1) Verify quality testing, 2) Maintain production processes, 3) Implement processing principles and techniques, 4) Improve manufacturing processes, and 5) Install tooling and material. Based on the criticality number these five duties are very critical to an employer and the plastics technologists for success.

Duty A. Support Administration Goals	**Criticality**
Review timeline for goals	8.444
Evaluate completed projects	8.259
Review goals of management	6.333
Obtain company vision & goal statement	6.333
Review resources for goals	5.148
Track budget for goals	2.370
Review budget for goals	2.111
Evaluate project budget goals	2.111
Duty B. Implement Processing Principles and Techniques	
Participate in process failure mode effects analysis	12.519
Evaluate quality of material	12.000
Confirm material characteristics	11.814
Document process parameters	11.148
Identify process parameters	10.111

Continued

Table 4.17: Duty/Task Criticality

Table 4.17 continued

	Criticality
Identify control parameters	9.852
Determine raw material requirements	8.777
Determine regrind effects on product and process	8.704
Determine temperature and time requirement	7.333
Determine pressure requirements	7.185
Evaluate dryness of material, % moisture	7.148
Define melt viscosity	5.741
Duty C. Install Tooling and Material	
Define plastic mfg. process	9.481
Determine tooling/mold installation procedures	8.555
Document process parameters	7.333
Review raw material selection criteria	7.148
Review process line layout	6.481
Select appropriate mold and tooling	4.963
Duty D. Maintain Production Processes	
Troubleshoot process parameters	13.519
Implement process parameters	11.481
Analyze process data	10.185
Monitor process controls	9.629
Determine customer specifications	9.037
Duty E. Provide Manufacturing Related Training	
Evaluate training feedback	7.666
Conduct employee training	6.777
Identify training needs	6.185
Provide documentation for training received	4.481
Create training package	3.778
Schedule employee training	2.000

Continued

Table 4.17 continued

Duty F. Verify Quality Testing	**Criticality**
Determine solution to problem	14.333
Identify manufacturing problem	14.222
Implement manufacturing changes	10.370
Evaluate manufacturing effectiveness of changes	10.148
Perform technical tests	7.815
Document manufacturing changes and results	7.555
Document test results	6.519
Analyze results of tests	5.296
Provide results to customer or agency	3.135
Duty G. Arrange Logistics of Stock Keeping Units	
Confirm starter material located at work center	7.444
Identify presence of starter material	5.370
Verify correct SKU (end line clearance)	5.185
Verify correct product SKU (beginning line clearance)	2.593
Procure SKU (stock keeping unit) bill of material	1.852
Duty H. Maintain Equipment	
Maintain equipment periodic maintenance	8.370
Analyze effectiveness of maintenance	7.963
Maintain preventative maintenance schedule	6.963
Monitor preventative maintenance schedule	6.111
Maintain daily housecleaning schedule	4.148
Duty I. Improve Manufacturing Processes	
Gather improvement ideas	11.259
Define improvement cost savings	10.777
Present improvement to management	10.222
Evaluate mfg. process needs	9.037
Identify opportunities for automation	8.185

Continued

Table 4.17 continued

	Criticality
Provide training on improved equipment	6.037
Initiate improvement project	5.963
Assist in installing improvement equipment	3.592
Prepare facility action plan	2.593
Prepare facility drawings	1.666
Duty J. Implement Part Design Procedure	
Determine material & process relation	6.518
Identify part design characteristic	6.037
Identify material thickness criteria	6.000
Determine value engineering cost trade-offs in part design	5.444
Identify parts service life base on environment	3.407
Duty K. Maintain Personal Development	
Participate in mandatory job-related training	7.888
Read industrial publications for new technology	6.296
Complete annual OSHA/EPA training	5.000
Create personal development plan	4.888
Attend professional meetings for new technology	4.704
Present personal development plan to mgt.	4.629
Acquire regulatory certification	4.333

In Table 4.18 criticality is ranked in descending order for the occupation of industrial plastics technologists. The resulting "criticality" product is using a arbitrarily chosen 9.000 cutoff point and above for deciding what is important to plastics technologists.

Many similar high means and high criticality number tasks were found in Table 4.10 (Task Importance Means), Table 4.11 (Task Difficulty Means), and Tables 4.17 and 4.18.

	Criticality
Determine solution to problem	14.333
Identify manufacturing problem	14.222
Troubleshoot process parameters	13.519
Participate in process failure mode effects analysis	12.519
Evaluate quality of material	12.000
Confirm material characteristics	11.814
Implement process parameters	11.481
Gather improvement ideas	11.259
Document process parameters	11.148
Define improvement cost savings	10.777
Implement manufacturing changes	10.370
Present improvement to management	10.222
Analyze process data	10.185
Evaluate manufacturing effectiveness of changes	10.148
Identify process parameters	10.111
Identify control parameters	9.852
Monitor process controls	9.629
Define plastic mfg. process	9.481
Determine customer specifications	9.037
Evaluate mfg. process needs	9.037
Determine raw material requirements	8.777
Determine regrind effects on product and process	8.704
Determine tooling/mold installation procedures	8.555
Review timeline for goals	8.444
Maintain equipment periodic maintenance	8.370
Evaluate completed projects	8.259
Identify opportunities for automation	8.185
Analyze effectiveness of maintenance	7.963
Participate in mandatory job-related training	7.888
Perform technical tests	7.815

Continued

Table 4.18 Criticality of Plastics Technologists Tasks

Table 4.18 continued

	Criticality
Evaluate training feedback	7.666
Document manufacturing changes and results	7.555
Confirm starter material located at work center	7.444
Determine temperature and time requirement	7.333
Document process parameters	7.333
Determine pressure requirements	7.185
Evaluate dryness of material, % moisture	7.148
Review raw material selection criteria	7.148
Maintain preventative maintenance schedule	6.963
Conduct employee training	6.777
Document test results	6.519
Review process line layout	6.481
Review goals of management	6.333
Obtain company vision & goal statement	6.333
Identify training needs	6.185
Initiate improvement project	5.963
Define melt viscosity	5.741
Determine value engineering cost trade-offs in part design	5.444
Identify presence of starter material	5.370
Analyze results of tests	5.296
Verify correct SKU (end line clearance)	5.185
Review resources for goals	5.148
Complete annual OSHA/EPA training	5.000
Select appropriate mold and tooling	4.963
Create personal development plan	4.888
Attend professional meetings for new technology	4.704
Present personal development plan to mgt.	4.629
Provide documentation for training received	4.481
Acquire regulatory certification	4.333
Maintain daily housecleaning schedule	4.148
Create training package	3.778
Assist in installing improvement equipment	3.592
Identify parts service life base on environment	3.407
Provide results to customer or agency	3.148

Continued

Table 4.18 continued

	Criticality
Verify correct product SKU (beginning line clearance)	2.593
Prepare facility action plan	2.593
Track budget for goals	2.370
Review budget for goals	2.111
Evaluate project budget goals	2.111
Schedule employee training	2.000
Procure SKU (stock keeping unit) bill of material	1.852
Prepare facility drawings	1.666

The criticality number allows a person to look at individual duties and each task associated with a duty and decides what is most important to teach. Then by comparing the other survey data Sinclair Community College has a good understanding of employer needs.

Summary

The data from this task survey did not have large gaps in standard deviation and in most cases had above average means. This is an indicator of homogenous data from both the expert DACUM panel and the responders to the survey. Thus good practical data was derived from the survey which will help in structuring curriculum for the plastics courses and future curriculum at Sinclair Community College.

The important ranking of duties and tasks starting with the expert DACUM panel and finishing with the task verification survey has been realized. This survey and the research data from the survey have answered the three research questions and verified that the expert DACUM panel closely matched the research data findings. The research instrument used had vey high reliability and non-response error was avoided by using a double dipping method.

The integration of components for the criticality number provides another measurement to access duties and tasks. Then by accessing scores of entry level, task performance, task difficulty, and by adding enablers should provide good indicators for curriculum direction and development at Sinclair Community College**.** This data will provide a better understanding for the demand side of education.

Research results comparing education levels of responders between high school through apprenticeship and associate through bachelors degrees led to interesting findings. A significant difference in means emerged comparing the two groups. The enablers critical to job performance for the high school through apprenticeship group were personality traits. The enablers for the associate through bachelors degrees group were course content related for their job performance. The data indicates a gap between the two groups due to education level achieved. This could be a knowledge and skill gap, which could stifle both the employee and the employer.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes the preceding chapters, draws conclusions based on the survey data, and presents recommendations. The conclusions and recommendations are limited to industrial plastics technologists from the greater Dayton, Ohio area.

Summary

The field of plastics continues to grow in the U.S. and particularly in Ohio where plastics is the leading export product. As the field of plastics expands with new materials, as it has for over one hundred years, the requirement for new processes, new process equipment and tooling, and talented employees with the skills to be successful in this industry becomes very high. The skill sets that the plastics technologists possess is the foundation for higher levels of employment in the polymer field. The higher levels include the newer technologies of composites, nanotechnology, and nanodispersion, to name a few. The purpose of this study was to identify the duties and tasks of plastics technologists in the greater Dayton, Ohio area. With this occupational information the researcher will improve and expand current curriculum at Sinclair Community College. Specifically, the study sought to answer the following three questions:

- **First research question**, “What are the duties and tasks that manufacturing employers need for a manufacturing plastics technologist to perform?”
- **Second research question**, “What are the entry level tasks as indicated by a census of manufacturing plastics technologists?”
- **Third research question,** “How do manufacturing plastics technologists rate the tasks on **importance to the job** and **difficulty to perform**?”

The plastics industry in the U.S. has recognized that the field of polymers is firmly implanted into the economy and that this industry is severely deficient in a skilled workforce. Many studies have been made to determine manufacturing skills gap, however the researcher found these to be very general and not specific to the plastics industry in the greater Dayton area. With this study the researcher sought to reduce the skills gap between what employers need and what Sinclair Community College is teaching. The literature points to this need with findings of a 40 percent gap between what employers need and what educational institutions are teaching.

On January 3 and 4th, 2008, a DACUM workshop was held with eight volunteer industrial plastics technologists serving as expert panel members. These expert panel members were a cross section of various plastics industries, with different years of experience, and ethnic and gender backgrounds. Each expert panel member was initially recommended by a third party industrial society and the researcher used a convenience sampling technique to insure a quality and diverse expert group, representative of the greater Dayton, Ohio area.

The population of this research study consisted of 29 plastics manufacturing companies that perform various plastic manufacturing processes. This population came from three 2008 Ohio Manufacturing Directories. The companies were contacted and interviewed for the criteria they needed to qualify for this survey. The company had to manufacture plastic products, have 50 or more employees, and reside in one of nine counties within the greater Dayton area. After eliminating many companies due to size, non manufacturing, etc. the population became 29. The company managers of the population companies were asked to identify highly experienced and successful plastics technologists from within their organization. The plastics technologists were contacted about the survey and asked if they would volunteer. After volunteering the surveys were mailed to each survey taker (hereafter called a responder) with a self-addressed envelope for the return. The researcher had a return rate of 100 percent using a survey technique called "double-dipping," but only used the actual 27 returned surveys due to one survey, which was a highly suspect outlier and the other a verbal interview.

The respondents were asked to determine whether each of the 78 tasks from the DACUM process is performed by an entry level plastics technologist? Each respondent was then asked to rate each tasks importance and task difficulty. Finally the responders were asked to rate enablers and answer demographic information. The responses were ranked and analyzed using frequency, mean, standard deviation, and a criticality calculation.

Conclusions

The following conclusions were derived from the analyses?

- The DACUM process was a proper choice to develop a duty and task list for plastics technologists in the greater Dayton, Ohio area.
- The occupation of plastics technologists' job is varied and consists of 11 broad duty areas.
- The 78 identified tasks are the basic performances required for successful preparation to enter employment as an industrial plastics technologist in the greater Dayton area.
- No task was rated "not at all important," therefore, it was concluded that an adequate curriculum for industrial plastics technologists in the greater Dayton, Ohio area must include all 78 identified tasks.
- Plastics technologist students in the greater Dayton area should be competent in all 78 tasks identified by this research study to be successful.

- Plastics technologists in the greater Dayton area could be required to use most of the 78 tasks identified upon their initial job entry.

Recommendations

This research study used the DACUM process to identify the occupation of plastics technologists and their duties and tasks that need to be performed by practicing technologists in the greater Dayton, Ohio area. The result of the DACUM was the development of a task verification survey instrument, which was sent to volunteer practicing plastics technologists for their input. Based on a review of previous literature this duty and task survey was the first ever to take place in Dayton, Ohio.

It is recommended that further research be conducted to investigate the following:

1. Conduct a duties and task study specifically pertaining to the injection molding industry in the Dayton area where the same process equipment is being used for plastics, ceramics and metallic parts. This is the leading plastics process in the Dayton area with many non-overlapping duties.
2. Conduct a longitudinal study by duplicating this one in three to five years. This could show improvements in curriculum and focus on newer technologies.
3. Conduct a duties and task study with a narrower focus on the three major plastics processes in Dayton. The processes of injection molding, extrusion

and fiberglass reinforced plastics are the three leading manufacturing processes at this time. This study could fine-tune specific duties and tasks pertaining to those processes.

4. Conduct a study targeting top company officials (presidents) to determine what they look for in plastics technologists. This could help academia understand why plastics manufacturers do not send more of their employees to SCC for training.
5. Conduct a study of plastics technologists targeting different education levels starting with high school through the Ph.D. and score how responders rate enablers. This expanded study will help SCC determine the knowledge and or skills gap that exists. This could lead to development of an introductory course with a focus on new process technology, materials, methods, and tooling.

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APPENDICES

APPENDIX A

LETTER FROM THE DAYTON TOOLING AND MANUFACTURING ASSOCIATION

DTMA
DAYTON TOOLING AND MANUFACTURING ASSOCIATION

240 West Fifth Street, Room 13-125
Dayton, Ohio 45402-2302
(937) 512-3862 • (937) 512-3224 Fax
www.dtma.org • email: generalinfo@dtma.org

Serving the tooling, machining, and manufacturing community in the greater Dayton region

April 3, 2007

Mr. David G. Meyer, MBA, PE
Associate Professor
Engineering & Industrial Technology Division
Sinclair Community College
444 West Third Street Building 13-210
Dayton, Ohio 45402-1460

Dear David:

Based on your request, you have our approval to use the Dayton Tooling and Manufacturing Association's (DTMA) name in support of your manufacturing survey initiative with the Internal Research Board at The Ohio State University.

The DTMA understands the purpose of the research study is to determine manufacturing course and content needs that will close the skills gap which is facing manufacturing today. This proposed survey study will determine the skill requirements of technical employees that will allow manufacturing companies to prosper. DTMA finds that your proposed survey closely aligns with a skills gap study we need to conduct as part of the implementation of the Dream !t, Do !t manufacturing careers campaign designed by the National Association of Manufacturers. Thus, your significant research study, combined with our study needs, will lay the foundation for curriculum change at Sinclair Community College and possibly at other institutions. For manufacturers in the Dayton area, the outcome has positive implications for new job skills, a culture change in the workplace, and continued financial growth.

Sincerely,

Angelia M. Erbaugh
Executive Director

APPENDIX B

LETTER FROM SINCLAIR COMMUNITY COLLEGE

Sinclair Community College, 444 West Third Street, Dayton, Ohio 45402-1460

April 5, 2007

David G. Meyer, MBA, PE
Associate Professor Industrial,
Manufacturing & Plastics
Engineering Technology
Sinclair Community College
444 West Third St., Bldg. 13-210
Dayton, OH 45402-1460

Dear David,

This letter is being sent to advise you of Sinclair Community College's endorsement of your proposed Montgomery county manufacturing survey. You have my approval to use the Sinclair Community College name and that of our department in your cover letter to the Internal Research Board at The Ohio State University.

The purpose of your proposed research study, to determine manufacturing course and content needs that will close the skills gap for manufacturers, will assist curriculum changes at Sinclair Community College and possibly at other institutions. This is a critical time for Dayton area manufacturers and this important survey will help us better align our curriculum offerings with their needs.

Sincerely,

Shep Anderson
Chair, Industrial,
Manufacturing & Quality
Engineering Technology
Sinclair Community College
444 West Third St., Bldg. 13-210
Dayton, OH 45402-1460

APPENDIX C

LETTER FROM THE

NATIONAL CENTER FOR MANUFACTURING EDUCTION

NCME
National Center for Manufacturing Education

April 10, 2007

Mr. David G. Meyer
Associate Professor Industrial,
Manufacturing & Plastics Engineering Technology
Sinclair Community College
444 West Third St., Bldg. 13-210
Dayton, OH 45402-1460

Dear David,

RE: Letter of Support

The National Center for Manufacturing Education (NCME) would like to offer its support in your manufacturing research initiative with the Internal Research Board at The Ohio State University. NCME understands the purpose of the research study is to determine manufacturing course and content needs that will close the skills gap, which is facing manufacturer's today. Your Montgomery county manufacturing survey will determine what technical job skills employees' need that will allow manufacturing companies to prosper in the future. For manufacturers in the Dayton area, the outcome has many positive implications for new job skills and continued financial growth. Your research survey also matches our interest in job skills and workers nationwide according to the Manufacturing Skill Standards Council (MSSC) for technical skill and knowledge requirements.

Located at Sinclair Community College in Dayton Ohio, the NCME has been designated by the National Science Foundation as its national resource center for manufacturing education. The NCME founded in 1995 was one of the first three Centers of Excellence funded by the ATE program.

The NCME is home to the Manufacturing Education Resource Center (MERC), an electronic clearinghouse of high quality materials in manufacturing technology education. Through our network of educators and industry professionals nationwide, MERC can provide an ideal forum for the dissemination of new course curriculum or content that your survey reveals.

The NCME supports your interest in seeking the needed skills in manufacturing today. Your efforts will greatly assist in changing the traditional image of manufacturing, into a highly-skilled and efficient workforce. Problem-solving, critical thinking, creativity and innovation skills are necessary to compete on a global basis and are the formula for 21st century success.

Sincerely,

Monica a. Pfarr

Monica Pfarr
Director

A Partnership Between Sinclair Community College and the University of Dayton
444 West Third Street • Dayton, Ohio 45402-1460 • Phone 937-512-5357 • Fax 937-512-2394 • www.ncmeresource.org

Sinclair Community College — National Science Foundation — University of Dayton

APPENDIX D

LETTER FROM POLYMEROHIO

OH!Polymer
PolymerOhio, Inc.

December 7, 2007

David G. Meyer, MBA, PE
Associate Professor, Industrial,
Manufacturing & Plastics
Engineering Technology
Sinclair Community College
444 West Third St., Bldg. 13-210
Dayton, OH 45402-1460

Dear David,

PolymerOhio, Inc., an Ohio Edison Technology Center, is pleased to learn of your proposed Dayton area manufacturing survey. We understand you will be surveying the duties and tasks of engineering technologists in the plastics field.

The purpose of your proposed research study is to determine the employer's needs that will close the skills gap for manufacturers of plastics and composite products. The study outcome will then guide curriculum changes at Sinclair Community College and possibly at other institutions throughout the state.

This is a critical time for all Dayton area manufacturers as the required skill level for the workforce has increased significantly and is expected to continue to rise over the next decade. This important survey will help align the needed curriculum offerings. The results can be extrapolated across the state and will be applied in PolymerOhio's ongoing initiatives to increase the number of students studying plastics technology and to provide students with the skills that are missing now in the Ohio workforce.

We support this important research the results of which will assist PolymerOhio as well as other organizations in better understanding the needs of polymer companies for plastics technologists and in devising appropriate curricula for training students for these positions. We will be pleased to assist in any way.

Please inform the Internal Research Boards at Sinclair Community College and The Ohio State University of our support and interest in the outcomes of your proposed research.

Please let us know how we can help. Your personal affiliation with PolymerOhio since its inception has been invaluable. We hope we can provide similar value in supporting this important research.

Sincerely,

RL Markham

Richard Markham
Vice President, Programs
PolymerOhio, Inc.

Ohio | Department of Development

PolymerOhio, Inc. is an Ohio Edison Technology Center

155 Commerce Park Drive, Suite 8
Westerville, OH 43082
www.polymerohio.com

APPENDIX E

LETTER FROM THE SOCIETY OF MANUFACTURING ENGINEERS

EDUCATION
FOUNDATION

One SME Drive
P.O. Box 930
Dearborn, MI
48121-0930 USA

ph: (313) 425-3300
(866) 547-6333
fax: (313) 425-3411

Cecil W. Schneider, FSME, PE
President
CEC Technologies

February 20, 2008

David G. Meyer, MBA, PE
Associate Professor, Industrial,
Manufacturing & Plastics
Engineering Technology
Sinclair Community College
444 West Third St., Bldg. 13-210
Dayton, OH 45402-1460

Dear David,

The Society of Manufacturing Engineers Education Foundation (SME EF) has learned of your proposed greater Dayton area manufacturing survey in the field of plastics. I support this initiative with the Internal Research Board at The Ohio State University. I understand you will be surveying the duties, tasks and skills of engineering technologists in the plastics field.

I understand the scope of the research study is to determine manufacturing course and course content needs that will close the skills gap, which is facing manufacturing today. This proposed study will determine the skills employees' need that will allow manufacturing companies to prosper in the future.

This proposed survey is in keeping with industries current vision of educating students with relevant technology, innovation techniques and the needed job skills for success. This outcome has potential for positive implications for new job skills, a culture change in the workplace, and continued financial growth.

I wish you well in the research endeavor.

Sincerely,

Steve Quinlan
Senior Program Officer
SME Education Foundation

APPENDIX F

PLASTICS IN OHIO

Plastics in Ohio

Major Plastics Manufacturing Areas in Ohio

Toledo Area - $3 billion GDP

Cleveland Area - $8 billion GDP

Dayton Area - $5 billion GDP

Ohio leads in plastics production in the U.S. and in GDP at $17.5 billion annually

(Harris Ohio, 2008)

APPENDIX G

RESEARCH TIMELNE

TIMELINE

Objective	Task	Description	Jan 08	Feb 08	Mar 08	April 08	May 08	Jun 08	Jul 08	Aug 08
1		Conduct DACUM								
	A	Secure Sinclair's IRB approval	■							
	B	Secure an eight member team of experts	■							
	C	Conduct DACUM process	■							
2		Develop Survey Instrument								
	A	Validate DACUM duties/tasks/skills	■	■						
	B	Formulate into survey questions		■	■					
	C	Develop questionnaire		■	■	■				
	D	Field review questionnaire					■			
	E	Secure OSU's IRB approval					■			
3		Administer Survey Instrument								
	A	Determine plastic manufacturing companies population		■						
	B	Random sample companies					■			
	C	Initial contact with top company officer					■			
	D	Send survey instrument					■	■		
	E	Do follow-ups for non-responding surveys						■		
	F	Analysis survey data						■		
	G	Compile all data and write report on findings						■	■	
4		Dissertation								
	A	Finish research							■	■
	B	Finish dissertation								■

APPENDIX H

SINCLAIR COMMUNITY COLLEGE'S IRB APPROVAL

TO DO DACUM

December 13, 2007

Mr. David Meyer
Associate Professor
Sinclair Community College
444 West Third St.
Dayton, OH 45402

Re: IRB Review of your proposal *"Manufacturing Engineering Technology Curriculum to Meet the Polymer (Plastics/Composites) Industry Needs in the Greater Dayton Area"*

Dear Mr. Meyer:

As chair of the Sinclair Institutional Review Board for the Protection of Human Subjects (IRBOOO05624), I have reviewed the proposal noted above with you as principle investigator. This proposal has been determined to meet federal research exemption 2 criteria, and as result is exempt from the full IRB review under Section 101, subsection b.1 and compliant with Sinclair protocols.

Therefore, I approve the application.
Good luck with your venture.

Sincerely,

Joan Patten
Director, Research, Analytics, & Reporting Chair
Sinclair Institutional Review Board

APPENDIX I

SINCLAIR'S IRB EXPERT PANEL INFORMED CONSENT FORM

Sinclair Community College

EXPERT PANEL INFORMED CONSENT FORM

Proposal Title: "Manufacturing Engineering Technology Curriculum to Meet the Polymer (Plastics/Composites) Industry Needs in the Greater Dayton Area"

Principal Investigator: David. G. Meyer

Dear Panel Member/Recorder:

We are conducting a study to determine the duties and tasks of entry level technologists in the plastics field. In this study, you will be asked, what are the current duties; tasks; general knowledge and skills; worker behaviors; tools, equipment, supplies and materials; and future trends and concerns of polymer practitioners (engineering technologists). An engineering technologist has either a 2-year Associates or 4-year B.S. Degree in manufacturing or industrial engineering technology with courses in plastics. Your participation should take two days or less.

There are no risks to you in this research study. The information you provide will be organized into a survey questionnaire and mailed to area polymer practitioners for verification of duties and tasks. The possible benefits from this study include: upgrading current Sinclair Community College plastics curriculum to match it with employer needs (this will help close the skills gap), your volunteering for this project is a good community service with strong future economic value, and this new obtained knowledge could help other institutions throughout the state.

All information will be handled in a strictly confidential manner, so that no one will be able to identify you when the results are recorded/reported.

Your participation in this study is totally voluntary and you may withdraw at any time without negative consequences. If you wish to withdraw at any time during the study, simply contact me ASAP.

Please feel free to contact David G. Meyer, Associate Professor in OPT (937-512-2175) if you have any questions about the study. Or, for other questions, contact Sinclair's Director of Research, Analytics, and Reporting (937-512-2558).

I understand the study described above and have been given a copy of the description as outlined above. All the questions I have raised have been answered to my full satisfaction. I am 18 years of age or older and I agree to participate.

Signature of Participant ________________________ Date _____________

APPENDIX J

SINCLAIR'S DACUM EXPERT PANEL

DEMOGRAPICS FORM

PANEL DEMOGRAPHICS

January 4 and 5, 2008

This is a brainstorming event where you will be deciding through a consensus process the “duties and tasks” of an entry level plastic technologist with a 2 or 4-year college degree.

During the process we will be prioritizing which duties and tasks are more important.

Name:

Phone:

E-mail:

Address:

Years of work experience:

(Circle one)
Education HS Apprentice Associates Degree BS Degree MS Degree Other

Thank you in advance for your help.

David G. Meyer

Associate Professor

APPENDIX K

THANK YOU LETTER TO EXPERT

DACUM PANEL

January 28, 2008

Dear _______________,

Thank you for your assistance in the DACUM (Developing A Curriculum) workshop which was conducted at Sinclair Community College, early in January 2008. Your valuable time has helped Sinclair Community College, its curriculum, its students, and the local companies who hire our students.

Attached please find a copy of the DACUM job sheet with the duties, tasks and skills that were identified for a Plastics Technologist. If you see any further changes that should be made on the job sheet, please advise. Phone: 937-512-2175 or email: david.meyer@sinclair.edu

Sincerely,

David G. Meyer
Associate Professor, Manufacturing Engineering Technology
Sinclair Community College
444 West Third Street, Bldg. 13-210
Dayton, Ohio 45402-1460

APPENDIX L

TASK VERIFICATION SURVEY

(fifteen pages in this survey)

PART 1 - TASK & KNOWLEDGE/SKILL STATEMENTS

Instructions: Please read very carefully!

On the pages that follow, you will find a **list of duties** followed by **task statements** clustered into 11 major duties (A through K) that relate to the job of Plastics Engineering Technologists. Each duty will have many task statements. We need your personal reaction to these three questions regarding each task statement:

1. Does an entry level plastics technologist **perform** this task?
2. How **important** is this task in the performance of **your job**?
3. How **difficult** is it to perform this task?

Answer these questions by completing the following steps:

1. For each task in Duty A circle all your responses, indicating first whether an entry level plastics technologist **performs** this task in the **Perform** column **1**. Then indicate how **important** you believe this task is in the performance of your job in the **Task Importance** column **2.** Choose and circle the number that most accurately reflects the importance of that task in your job as a Plastics Engineering Technologists. If you do not perform some of the tasks because they are another plastics technologist's responsibility in your company, please circle the number that indicates how important you believe those tasks are to the overall success of a Plastics Engineering Technologists in your company. If a secretary or other non-technical person independently performs some of the tasks mark them as, **Not at all Important (0)** to your job as a Plastics Engineering Technologists. Use the scale below to rate the importance of each task:

   5 = Of **Extremely importance** **Here performance is critical** to success of a Plastics Engineering Technician/Technologists.
   4
   3
   2
   1
   0 = Of **No importance** **Here performance makes no contribution** to success or is not performed by a Plastics Engineering Technologists.

2. **Add** any **additional statements** to Duty A (last line) then **rate** the **importance** of these **statements** that describe any other tasks that you have performed or that you feel need to be performed by a Plastics Engineering Technologists. If you feel that any of the listed statements are incorrect or need clarification, please **modify** or **rewrite** them.

3. For each of the statements in Duty A that **you perform** and rated to be of **some task importance** (i.e., 1-5) column **2**, indicate the **difficulty** to perform each task in the **Task Difficulty** column **3**. Assume the person has the type of education and previous experiences that are typical for someone with a job as a Plastics Engineering Technologists. Use the scale below to indicate the difficulty of learning to perform each task:

   5 = **Extremely difficult** The task is extremely **difficult** to perform.
   4
   3
   2
   1
   0 = **Extremely easy** The task is extremely **easy** to perform; no training is needed.

4. Repeat Steps 1-3 for each of the remaining duty areas.

5. Check the inventory of task statements to be sure that you have responded to the three questions for each statement. For or those tasks you or other Plastics Engineering Technologists **do not perform** and indicated **Not at all Important (0)** in column **2**, then skip **Task Difficulty** in column **3**. Also, be sure to **rate** any task statements you have **added** or **modified.**

6. Then, move on to Part II of this questionnaire to rate the (1) General Knowledge and Skills, (2) Worker Behaviors, (3) Tools, Equipment, Supplies, & Materials, and (4) Future Trends and Concerns, that are relevant to the Plastics Engineering Technologists. Finally, complete Part III, which will provide important descriptive information about you and related issues. Be assured that all responses will be kept confidential and only group data will be reported.

Plastics Engineering Technologist Task Verification Survey	**1. Perform** Does an entry level plastics technologist **PERFORM** this task?		**2. Task Importance** How **IMPORTANT** is this task in the performance of your job? (Circle ONE response)						**3. Task Difficulty** How **DIFFICULT** is it to perform this task? (Circle ONE response)					
NOTE: Please be sure you have read the preceding instructions carefully before continuing. Circle the correct response for each question.	**Yes**	**No**	**Not at all Important**			**Extremely Important**			**Extremely Easy**			**Extremely Difficult**		
Duty A. Support Administration Goals														
1. Obtain company vision & goal statement	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
2. Review goals of management	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
3. Review resources for goals	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
4. Review budget for goals	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
5. Review timeline for goals	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
6. Track budget for goals	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
7. Evaluate project budget goals	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
8. Evaluate completed projects	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
9.	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
10.	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
Duty B. Implement Processing Principles and Techniques														
1. Determine raw material requirements	Y	N	0	1	2	3	4	5	0	1	2	3	4	5

Plastics Engineering Technologist Task Verification Survey	1. Perform Does an entry level plastics technologist **PERFORM** this task?		2. Task Importance How **IMPORTANT** is this task in the performance of your job? (Circle ONE response)						3. Task Difficulty How **DIFFICULT** is it to perform this task? (Circle ONE response)					
NOTE: Please be sure you have read the preceding instructions carefully before continuing. Circle the correct response for each question.	**Yes**	**No**	**Not at all Important**				**Extremely Important**		**Extremely Easy**				**Extremely Difficult**	
2. Determine temperature and time requirement	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
3. Determine pressure requirements	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
4. Define melt viscosity	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
5. Evaluate dryness of material, % moisture	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
6. Determine regrind effects on product and process	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
7. Confirm material characteristics	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
8. Evaluate quality of material	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
9. Identify process parameters	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
10. Identify control parameters	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
11. Document process parameters	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
12. Participate in process failure mode effects analysis	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
13.	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
14.	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
Duty C. Install Tooling and Material														
1. Define plastic mfg. process	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
2. Review raw material selection criteria	Y	N	0	1	2	3	4	5	0	1	2	3	4	5

Plastics Engineering Technologist Task Verification Survey	1. Perform Does an entry level plastics technologist **PERFORM** this task?		2. Task Importance How **IMPORTANT** is this task in the performance of your job? (Circle ONE response)						3. Task Difficulty How **DIFFICULT** is it to perform this task? (Circle ONE response)					
NOTE: Please be sure you have read the preceding instructions carefully before continuing. Circle the correct response for each question.	**Yes**	**No**	**Not at all Important**			**Extremely Important**			**Extremely Easy**			**Extremely Difficult**		
3. Select appropriate mold and tooling	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
4. Determine tooling & mold installation procedures	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
5. Review process line layout	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
6. Document process parameters	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
7.	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
8.	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
Duty D. Maintain Production Processes														
1. Determine customer specifications	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
2. Implement process parameters	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
3. Monitor process controls	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
4. Analyze process data	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
5. Troubleshoot process parameters	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
6.	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
7.	Y	N	0	1	2	3	4	5	0	1	2	3	4	5

Plastics Engineering Technologist Task Verification Survey	**1. Perform** Does an entry level plastics technologist **PERFORM** this task?		**2. Task Importance** How **IMPORTANT** is this task in the performance of your job? (Circle ONE response)						**3. Task Difficulty** How **DIFFICULT** is it to perform this task? (Circle ONE response)					
NOTE: Please be sure you have read the preceding instructions carefully before continuing. Circle the correct response for each question.	**Yes**	**No**	**Not at all Important**				**Extremely Important**		**Extremely Easy**				**Extremely Difficult**	
Duty E. Provide Manufacturing Related Training														
1. Identify training needs	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
2. Create training package	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
3. Schedule employee training	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
4. Conduct employee training	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
5. Evaluate training feedback	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
6. Provide documentation for training received	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
7.	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
8.	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
Duty F. Verify Quality Testing														
1. Perform technical tests	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
2. Analyze results of tests	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
3. Document test results	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
4. Identify manufacturing problem	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
5. Determine solution to problem	Y	N	0	1	2	3	4	5	0	1	2	3	4	5

Plastics Engineering Technologist Task Verification Survey	1. Perform Does an entry level plastics technologist **PERFORM** this task?		2. Task Importance How **IMPORTANT** is this task in the performance of your job? (Circle ONE response)						3. Task Difficulty How **DIFFICULT** is it to perform this task? (Circle ONE response)					
NOTE: Please be sure you have read the preceding instructions carefully before continuing. Circle the correct response for each question.	**Yes**	**No**	**Not at all Important**			**Extremely Important**			**Extremely Easy**			**Extremely Difficult**		
6. Provide results to customer or agency	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
7. Implement manufacturing changes	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
8. Evaluate manufacturing effectiveness of changes	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
9. Document manufacturing changes and results	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
10.	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
11.	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
Duty G. Arrange Logistics of Stock Keeping Units														
1. Procure SKU (stock keeping unit) bill of material	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
2. Verify correct product SKU (beginning line clearance)	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
3. Identify presence of starter material	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
4. Confirm starter material located at work center	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
5. Verify correct SKU (end line clearance)	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
6.	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
7.	Y	N	0	1	2	3	4	5	0	1	2	3	4	5

Plastics Engineering Technologist Task Verification Survey	**1. Perform** Does an entry level plastics technologist **PERFORM** this task?		**2. Task Importance** How **IMPORTANT** is this task in the performance of your job? (Circle ONE response)						**3. Task Difficulty** How **DIFFICULT** is it to perform this task? (Circle ONE response)					
NOTE: Please be sure you have read the preceding instructions carefully before continuing. Circle the correct response for each question.	**Yes**	**No**	**Not at all Important**			**Extremely Important**			**Extremely Easy**			**Extremely Difficult**		
Duty H. Maintain Equipment														
1. Monitor preventative maintenance schedule	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
2. Maintain equipment periodic maintenance	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
3. Maintain preventative maintenance schedule	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
4. Maintain daily housecleaning schedule	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
5. Analyze effectiveness of maintenance	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
6.	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
7.	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
Duty I. Improve Manufacturing Processes														
1. Evaluate mfg. process needs	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
2. Gather improvement ideas	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
3. Identify opportunities for automation	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
4. Define improvement cost savings	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
5. Present improvement to management	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
6. Prepare facility action plan	Y	N	0	1	2	3	4	5	0	1	2	3	4	5

Plastics Engineering Technologist Task Verification Survey	**1. Perform** Does an entry level plastics technologist **PERFORM** this task?		**2. Task Importance** How **IMPORTANT** is this task in the performance of your job? (Circle ONE response)						**3. Task Difficulty** How **DIFFICULT** is it to perform this task? (Circle ONE response)					
NOTE: Please be sure you have read the preceding instructions carefully before continuing. Circle the correct response for each question.	**Yes**	**No**	**Not at all Important**			**Extremely Important**			**Extremely Easy**			**Extremely Difficult**		
7. Initiate improvement project	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
8. Prepare facility drawings	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
9. Assist in installing improvement equipment	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
10. Provide training on improved equipment	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
11.	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
12.	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
Duty J. Implement Part Design Procedure														
1. Determine value engineering cost trade-offs in part design	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
2. Identify parts service life base on environment	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
3. Identify part design characteristic	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
4. Identify material thickness criteria	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
5. Determine material & process relation	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
6.	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
7.	Y	N	0	1	2	3	4	5	0	1	2	3	4	5

Plastics Engineering Technologist Task Verification Survey	**1. Perform** Does an entry level plastics technologist **PERFORM** this task?		**2. Task Importance** How **IMPORTANT** is this task in the performance of your job? (Circle ONE response)						**3. Task Difficulty** How **DIFFICULT** is it to perform this task? (Circle ONE response)					
NOTE: Please be sure you have read the preceding instructions carefully before continuing. Circle the correct response for each question.	**Yes**	**No**	**Not at all Important**				**Extremely Important**		**Extremely Easy**				**Extremely Difficult**	
Duty K. Maintain Personal Development														
1. Create personal development plan	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
2. Present personal development plan to mgt.	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
3. Complete annual OSHA/EPA training	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
4. Participate in mandatory job-related training	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
5. Acquire regulatory certification	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
6. Attend professional meetings for new technology	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
7. Read industrial publications for new technology	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
8.	Y	N	0	1	2	3	4	5	0	1	2	3	4	5
9.	Y	N	0	1	2	3	4	5	0	1	2	3	4	5

Part II

For the following lists, indicate the degree to which each factor is critical to your performance on the job by circling all your responses in the appropriate box. For Future Trends and Concerns, indicate the degree to which you believe each factor WILL BE critical to performance.

1. General Knowledge and Skills

	0 = Not at all critical to job performance					5 = Extremely critical to job performance
1. Communication (oral & written)	0	1	2	3	4	5
2. Troubleshooting	0	1	2	3	4	5
3. Coaching	0	1	2	3	4	5
4. Mentoring	0	1	2	3	4	5
5. Math	0	1	2	3	4	5
6. Analytical	0	1	2	3	4	5
7. Planning	0	1	2	3	4	5
8. Spreadsheets	0	1	2	3	4	5
9. CAD (Computer Aided Design) (AutoCAD, solid works, Inventor)	0	1	2	3	4	5
10. Knowledge of Thermodynamics	0	1	2	3	4	5
11. Mechanical Applications	0	1	2	3	4	5
12. Multi-tasking	0	1	2	3	4	5
13. Blue print reading	0	1	2	3	4	5
14. Six sigma	0	1	2	3	4	5
15. Basic accounting	0	1	2	3	4	5
16. ISO (International Standards Organization) standards	0	1	2	3	4	5
17. Lean manufacturing	0	1	2	3	4	5
18. Knowledge of safety	0	1	2	3	4	5

19. Procedural writing (work instructions) skills	0	1	2	3	4	5
20. Organizational skills	0	1	2	3	4	5
21. Value engineering	0	1	2	3	4	5
22. FMEA (failure mode and effects analysis) for process	0	1	2	3	4	5
23. FMEA (failure mode and effects analysis) for design	0	1	2	3	4	5
24. Bar coding	0	1	2	3	4	5
25.	0	1	2	3	4	5
26.	0	1	2	3	4	5

2. *Worker Behaviors*

	0 = Not at all critical to job performance					5 = Extremely critical to job performance
1. Able to accept constructive criticism	0	1	2	3	4	5
2. Cooperative	0	1	2	3	4	5
3. Confident	0	1	2	3	4	5
4. Ability to interact with professionals/managers/customers	0	1	2	3	4	5
5. Drives for consensus	0	1	2	3	4	5
6. Decisive	0	1	2	3	4	5
7. Honest	0	1	2	3	4	5
8. Positive attitude	0	1	2	3	4	5
9. Dependable	0	1	2	3	4	5
10. Assertive	0	1	2	3	4	5
11. Efficient	0	1	2	3	4	5
12. Patient	0	1	2	3	4	5
13. Sense of humor	0	1	2	3	4	5
14. Safety conscious	0	1	2	3	4	5
15. Quick learner	0	1	2	3	4	5

16. Trustworthy	0	1	2	3	4	5
17. Non-smoker	0	1	2	3	4	5
18. Enthusiastic	0	1	2	3	4	5
19. Innovative	0	1	2	3	4	5
20. Team player	0	1	2	3	4	5
21. Self-starter	0	1	2	3	4	5
22. Goal oriented	0	1	2	3	4	5
23. Detail-oriented	0	1	2	3	4	5
24. Good listener	0	1	2	3	4	5
25. Integrity	0	1	2	3	4	5
26. Work ethic	0	1	2	3	4	5
27.	0	1	2	3	4	5
28	0	1	2	3	4	5

3. *Tools, Equipment, Supplies, & Materials*

	0 = Not at all critical to job performance					5 = Extremely critical to job performance
1. Safety equipment	0	1	2	3	4	5
2. Hand tools	0	1	2	3	4	5
3. Analysis tools	0	1	2	3	4	5
4. Inspection tools	0	1	2	3	4	5
5. Telephone/voice mail	0	1	2	3	4	5
6. Cell phone	0	1	2	3	4	5
7.	0	1	2	3	4	5
8.	0	1	2	3	4	5

0 = Will **Not** be critical to job performance

5 = Will be critical to job performance

4. *Future Trends and Concerns*

1. Empowerment of employees	0	1	2	3	4	5
2. Nanotechnology	0	1	2	3	4	5
3. Theory of Constraints	0	1	2	3	4	5
4. Outdated equipment	0	1	2	3	4	5
5. Experience gap in workforce	0	1	2	3	4	5
6. Lack of shop capacity for impact product	0	1	2	3	4	5
7. Lower volume lots	0	1	2	3	4	5
8. Quick changeover	0	1	2	3	4	5
9. Outsourcing	0	1	2	3	4	5
10. Increased production	0	1	2	3	4	5
11. Lack of training program for hourly employees	0	1	2	3	4	5
12. Increased safety culture	0	1	2	3	4	5
13. High employee turn-over	0	1	2	3	4	5
14. Supply chain management	0	1	2	3	4	5
15. Electric machines becoming more popular	0	1	2	3	4	5
16. Value-added production	0	1	2	3	4	5
17.	0	1	2	3	4	5
18.	0	1	2	3	4	5

PART III: GENERAL INFORMATION

Instructions: Read each item carefully and write or check where appropriate, your responses in the blanks provided:

My job title is: ________________________________

I have held this position for __________ years.
I have __________ years experience in plastics industry.

My highest education level is: Check only one

High school _____
Vocational school ____
Apprenticeship ____
Associates degree ____
Bachelors degree ____
Masters degree ____
Other (Please specify): ________________________________

Indicate with a number (1) the primary plastic process in your facility. With a number (2) indicate the other secondary processes (maybe more than one) in your facility.

Blow molding ____
Extrusion ____
Fiberglass reinforced plastic processor ____
Injection molding ____
Mold making ____
Reaction injection molding ____
Resin transfer molding ____
Rotational molder ____
Thermoforming ____
Other (Please specify): ________________________________

Thank you very much for completing this task verification survey!

Your name will be entered to win an iPod (your odds of winning is 1 in 30). Good luck!
Shep Anderson, Chair of Manufacturing Engineering Technology at Sinclair, will draw the winner.

CODE: __________________

APPENDIX M

THE OHIO STATE UNIVERSTY'S IRB APPROVAL

FOR SURVEY RESARCH

RECD MAY 0 1 2008

TITLE PAGE - APPLICATION FOR EXEMPTION FROM REVIEW BY THE INSTITUTIONAL REVIEW BOARD
The Ohio State University, Columbus OH 43[illegible]

For office use only
PROTOCOL NUMBER: 2008E0348

▶ **Principal Investigator**	Name: **Paul E. Post**	Phone: 614-292-7471
University Title: ☒ Professor ☐ Associate Professor ☐ Assistant Professor ☐ Instructor ☐ Other. Please specify. (May require prior approval.)	Department or College: College of Education and Human Ecology Diversity and Empowerment Student Organization (DESO), School of Teaching and Learning	E-mail: post.1@osu.edu
	Campus Address (room, building, street address): Rm 100 1100 Kinnear Rd. Columbus, OH 43212-1152	OSU ID# 84055202
	Signature: Paul E Post Date: 5/1/08	Fax: 614-292-2662

▶ **Co-Investigator**	Name: **David. G. Meyer**	Phone: 937-512-2175(W) 937-439-3950 (H)
University Status: ☐ Faculty ☐ Staff ☒ Graduate Student ☐ Undergraduate Student ☐ Other. Please specify.	Campus Address (room, building, street address) Sinclair Community College 444 West Third St., Bldg 13-210 Dayton, Ohio 45402-1460 or Home Mailing Address: 1375 Black Oak Dr. Dayton, Ohio 45459	E-mail: meyer.583@osu.edu
	Signature: David S Meyer Date: 5/1/08	Fax: 937-512-4530

▶ **Protocol Title**	**DACUM process for development of survey questions and conducting a survey.** **Proposal Title: Industrial Plastics Technologist's Duties and Tasks to Meet Employer Needs in the Greater Dayton Area**

▶ **Source of Funding**	Sinclair Community College, OPT Department for food and mailings

For Office Use Only

☒ **Approved.** ▶	Research has been determined to be exempt under these categories: #2 . Research may begin as of the date of determination listed below.
☐ **Disapproved.** ▶	The proposed research does not fall within the categories of exemption. Submit an application to the appropriate Institutional Review Board for review.

Date of determination: 5/06/08 **Signature:** Janet G. Schulte
Office of Responsible Research Practices

APPENDIX N

SINCLAIR COMMUNITY COLLEGE'S IRB APPROVAL

FOR SURVEY RESEARCH

May 7, 2008

Mr. David Meyer
Associate Professor
Sinclair Community College
444 West Third St.
Dayton, OH 45402

Re: IRB Review of your proposal *"Industrial Plastics Technologist's Duties and Tasks to Meet Employer Needs in the Greater Dayton Area"*

Dear Mr. Meyer:

As chair of the Sinclair Institutional Review Board for the Protection of Human Subjects (IRBOOO05624), I have reviewed the proposal noted above with you as principle investigator. This proposal has been determined to meet federal research exemption 2 criteria, and as result is exempt from the full IRB review under Section 101, subsection b.1 and compliant with Sinclair protocols. A signed, hard copy of your proposal will be provided through College internal mail.

Good luck with your venture.

Sincerely,

Joan Patten
Director, Research, Analytics, & Reporting Chair
Sinclair Institutional Review Board

APPENDIX O

POPULATION OF COMPANIES IN THE GREATER DAYTON AREA

The 29 Plastics Manufacturing Companies in the Greater Dayton, Ohio Area

1. Ashton Plastic Products, Inc.	15. InnaTech
2. Clopay	16. K & B Molded Products
3. Crayex Corp.	17. Kurz-Kasch, Inc.
4. Creative Extruded Product	18. MTM Molded Products
5. Deceuninck North America	19. MW Monroe Plastics
6. Dempsey Plastics	20. National Composite Center
7. Encon	21. Neaton
8. Evenflo Co., Inc.	22. Paragon Molding Ltd.
9. Florida Production Engineering	23. Plasco, Inc.
10. Freudenburg-NOK	24. Plastic Trim
11. Fox Lite	25. Proto Plastics
12. Granger Plastics	26. R.L. Industries, Inc
13. Green Tokai Company	27. Tech II, Inc.
14. Industrial Fiberglass Specialties	28. Tom Smith Industries Company
	29. Witt Plastics

APPENDIX P

SCRIPT TO COMPANY MANAGEMENT

The following script was used to introduce the researcher, screen the company for meeting research criteria, and encourage management to identify volunteer plastics technologists.

Script to Company Management

"Good morning/afternoon, I'm David Meyer, Associate Professor in Plastics Engineering Technology from Sinclair Community College in Dayton, Ohio.

To the receptionist: I am conducting a short survey of **duties and tasks** of Plastics Technicians/Technologist that could benefit students at Sinclair Community College and your company in future growth, and I need to talk to someone in management.

To the manager: I am conducting a short survey of **duties and tasks** of Plastics Technicians/Technologist that could benefit students at Sinclair Community College and your company in future growth and I need your help with is survey. All information is voluntary, held in strict confidence, and all survey responders will be entered to win an iPod and the odds of winning are 1 in 29. The survey takes about 30 minutes to answer all questions and I will be sending it to their home or business address, based on your request.

First, do you manufacture plastic product and have at least 50 employees?" If the answer is no to either part of the first question, the researcher will thank the manager for their time and phone the next company. If the answer is yes to both parts the researcher starts to probe for a Plastics Technologist's name. "I am requesting you to name one or possibly two of your better-than-average Plastics Technologist. Furthermore, I am seeking a good representation of Plastics Technologist (male, female, race, etc.) from the Greater Dayton area. This survey area is comprised of nine local counties around Dayton."

"Could you provide me the name of your better-than-average Plastics Technologist? Could you provide me another name to receive this survey? May I have their phone number, so I may contact them in advance? Thank you for your time and have a great day."

APPENDIX Q

SCRIPT TO TECHNOLOGIST TAKING SURVEY

The following script was used to introduce the researcher, indicate that this phone call is about a plastics technologist's survey, and who in their company recommended them for this survey.

Script used to Introduce the Survey Research Project to Technologist taking Survey

"Good morning/afternoon/evening, I'm David Meyer, Associate Professor in Plastics Engineering Technology from Sinclair Community College in Dayton, Ohio.

Recently you were recommended by, ___(Name)_________________, __(Title)___________ of ____(Company Name)______to participate in a survey questionnaire designed to determine the tasks, duties and skills of industrial plastics technicians/technologist in the greater Dayton area. Your participation is voluntary and your responses will remain confidential. This survey is OSU research in partial fulfillment of a Ph.D. in Technology Education at The Ohio State University. In addition, all survey responders will be entered to win an iPod and your odds of winning are 1 in 29.

This survey will benefit your company, the curriculum at Sinclair Community College, and possibly yourself. The organizations supporting this study include: PolymerOhio, The Society of Manufacturing Engineers, The National Center for Manufacturing Education (a National Science Foundation branch), Sinclair Community College, and the Dayton Tooling and Manufacturing Association.

The survey takes about 30 minutes to answer all questions. Will you volunteer to take this survey and return it? Do you wish for me to send this to your home or work address?

Get address etc. ______________________________

Optional phone number (cell) ____________________________

Thank you for you time."

APPENDIX R

SAMPLE COVER LETTER TO VOLUNTEER PLASTICS TECHNOLOGISTS

The following sample cover letter was included in the survey packet that was mailed to each volunteer plastics technologist. This cover letter, Sinclair's Survey Informed Consent letter, the task verification survey, and a self-addressed, postage paid, envelope for survey return completed each packet.

May ____________ 2008

Dear ______________,

Recently you were recommended by, ___(Name)________________, __(Title)__________ of ____(Company Name)______to participate in a survey questionnaire designed to determine the tasks, duties and skills of industrial plastics technicians/technologist in the greater Dayton area. Your participation is voluntary and your responses will remain confidential. This survey is Ohio State University research in partial fulfillment of a Ph.D. in Technology Education at The Ohio State University.

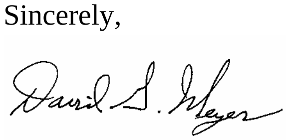
Please find attached the survey questionnaire I spoke about last week, while on the telephone. Thank you for agreeing to participate in this study. I am conducting this survey so that I may receive feedback and comments from previous DACUM (Developing a Curriculum) panel members.

This survey is examining the effectiveness of DACUM, as a process of occupational analysis. The specific area I am examining is the Plastics Technician/Technologists duties, tasks and skills within the greater Dayton, Ohio area. Your role in this survey is to add, change, delete or revise any items you feel necessary. Please mark your changes on the questionnaire, along with your responses.

All returned surveys will compete for an iPod, which will be given away. Your odds of winning are 1 in 30). Good luck to you! Shep Anderson, Chair of Manufacturing Engineering Technology at Sinclair Community College, will draw the winner.

Once again thank you for completing this survey. Your assistance is of great value to the study.

Sincerely,



David G. Meyer
Associate Professor, Manufacturing Engineering Technology
Sinclair Community College
444 West Third Street, Bldg. 13-210
Dayton, Ohio 45402-1460

APPENDIX S

SINCLAIR COMMUNITY COLLEGE'S SURVEY

INFORMED CONSENT FORM

This informed consent form for the volunteer plastics technologist's taking the survey was suggested by Sinclair Community College

INFORMED CONSENT

Dear Plastics Technologist:

We are conducting a study to determine duties, tasks, and skills of plastics technologists. In this study, you will be asked to respond to topics in the questionnaire. Your participation should take about 30 minutes.

All information will be handled in a strictly confidential manner, so that no one will be able to identify you when the results are recorded/reported.

Your participation in this study is totally voluntary and you may withdraw at any time without negative consequences. If you wish to withdraw at any time during the study, simply contact David Meyer, Associate Professor, at 937-512-2175 or email david.meyer@sinclair.edu.

Please feel free to contact me if you have any questions about the study. Or, for other questions, contact Sinclair's Director of Research Analytics & Reporting (937-512-2558).

I understand the study described above and have been given a copy of the description as outlined above. I am 18 years of age or older and I agree to participate.

Signature of Participant ______________________________ Date __________________

Print - Last, First and Middle Initial ____

APPENDIX T

MAIL FOLLOW-UP LETTER

FOR NON-RESPONSE

Mail Follow-up Letter

________________, 2008

Dear ______________,

Recently you were designated by, ___(Name)________________, __ (Title)__________ of ____(Company Name)______to participate in a survey questionnaire designed to determine the tasks, duties and skills of industrial plastics technicians/technologist in the greater Dayton area. Since we have not received your completed survey, another survey is enclosed. The success of this project depends on responses from you.

Your responses will remain confidential. Neither you nor your business will be identified in the reports prepared as a result of this survey. A code number has been assigned to the survey questionnaire and will only be used for follow-up like this. Won't you please take some time and complete the survey and return it in the enclosed addressed, stamped envelope by Monday? All returned surveys will compete for an iPOD, which will be given away. Your odds of winning are 1 in 30). Good luck to you! If you have already returned your survey, thank you!

Sincerely,

David G. Meyer
Associate Professor, Manufacturing Engineering Technology
Sinclair Community College
444 West Third Street, Bldg. 13-210
Dayton, Ohio 45402-1460

APPENDIX U

SAMPLE CRITICALITY CALCULATION

Criticality Sample Calculation

(Task Perform X Task Importance X Task Difficulty = Criticality)

Respondent	Task Perform	Task Importance	Task Difficulty	Criticality
Person 1	**0**	**3**	**2**	**0**
Person 2	**1**	**2**	**4**	**8**
----------	**---**	**---**	**---**	**---**
----------	**---**	**---**	**---**	**---**
Person 27	**1**	**3**	**5**	**15**
			Total	**270**

270/27 = 17.85 is the criticality calculation for this example