

A Competency Gaps Study for a Manufacturing Sequence Curriculum

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Abstract

This study was built on prior competency gap research conducted by the Society for Manufacturing Engineers to provide a foundation for the development of the Department of Technology's new Integrated Manufacturing Systems (IMS) laboratory at Illinois State University (ISU). The objectives of the study were to: a) investigate to what extent small and mid-sized Illinois manufacturing companies feel it is important for newly hired manufacturing engineering or technology graduates to possess specified basic personal skills, technical skills and business professional skills, b) compare the skills identified as important in this study with the SME competency gaps listing, and c) use the results of this study as one criteria to revise curriculum and update a laboratory in the IMS Sequence at ISU.

The methodology for this project consisted of randomly selecting small and mid-sized Illinois manufacturers from the 2004 Illinois Manufacturers Directory. The participants in the study completed a survey consisting of questions with regard to demographics, basic personal skills, technical skills, and business/professional skills. A 5 point likert scale was used.

The results of this study are being used to help modify a manufacturing curriculum and to renovate an existing laboratory with high technology automation hardware and software. A 1.2 million dollar donation from a manufacturing company is being used to help finance a major part of the initiative.

Introduction

This study sought formal funding for a line of research designed to enable the Integrated Manufacturing Systems (IMS) Sequence in the Department of Technology at Illinois State University (ISU) to maintain a strong contemporary focus. Maintaining contemporary laboratories and curriculum is critical to the advancement of the program and future of its graduates. The author has worked cooperatively with faculty in the sequence over the years to advance the curriculum and laboratories within the sequence. This work has resulted in several publications and presentations on rapid prototyping and lean manufacturing. Additionally, a \$135,000 grant from ABB Robotics was received to help improve an existing laboratory. Undergraduate and graduate students have worked with faculty on the rapid prototyping and robotics equipment to research alternatives to the implementation of this technology in the curriculum.

While the advancements in the IMS labs and curriculum have taken a giant leap forward in recent years, this is only the beginning of a major initiative that started with a proposal from the sequence in the latest capital campaign drive at ISU. The thrust of the proposal was to renovate a current laboratory with high technology automation hardware and software. The project will consist of the development of a high end, integrated manufacturing laboratory for the Department of Technology. The scope of integration will range from design for manufacturability, to process planning and process control, through data acquisition and managerial decision-making. This scope will not only ensure maximum utilization, it is also consistent with how technical, managerial and engineering functions are integrated in industry.

A large manufacturing company has pledged a donation of \$1,200,000 to help the IMS Sequence in its effort. Other funding is being sought from external funding agencies to support this initiative. However, data needed to be collected from a study to support the initiative and help the faculty be competitive in seeking other external funding. The SME Education Foundation only funds proposals that show (through studies or other means) where competency gaps exist in their curriculum and how the institution will help close these gaps. Consequently, the model that was used as the basis for this study was the SME competency gaps study.^[1]

The SME study has impacted the curriculum of manufacturing engineering and technology education programs across the country and been used as the basis for making funding decisions by the Education Foundation of this organization.^[2] The objective of the SME Foundation is to stimulate the academic community to help improve the competency of the manufacturing workforce. The MEP study focuses on identifying, and then closing, competency gaps between industry's manufacturing workforce needs and what is provided by educational programs.

While the study conducted by SME is beneficial, there were some missing elements that were essential for the ISU initiative. To begin with, the SME study focused on large manufacturers around the country. While some of the IMS Sequence graduates will be employed in these companies, there is a high likelihood that many will join small to mid-sized companies in Illinois. It was critical that the major initiative launched at ISU develop a high-end integrated manufacturing laboratory that meets the needs of the industrial constituency that the IMS Sequence serves. It was assumed that the study would add to the SME body of knowledge by focusing on small and mid-sized manufacturers in Illinois. More important, this study was expected to enhance the IMS faculty's understanding of the skills that are viewed as important by small and mid-sized manufacturers in Illinois. As a result, this could be used as one criterion to determine the type of curriculum and laboratory equipment needed to provide quality instruction.

Another element that was of importance in this context was the change that had taken place in the manufacturing industry since the 1999 study was done for the SME MEP. There had been rapid change in the U.S. economy and the manufacturing industry. The increasing globalization of U.S. manufacturing companies had taken a huge evolutionary leap in the last 3 to 5 years to the point of giving the appearance of a mass exodus of domestic production.^[3] Most recently, China has been the country most frequently associated with this exodus in the short time that they have been a member of the World Trade Organization.^[4] As McClenahen points out "China's rising economic status has both cast a dark shadow on U.S. industry and opened a passage to sunny prospects."^[5] This globalization of the manufacturing industry and perceived move of manufacturing to China have caused enough concern that a study was conducted by

Weinstein, Lewis and Bergeron on the impacts of international trade with China on Illinois manufacturers.^[6]

There has been a major shift in the manufacturing industry to maintain manufacturing competitiveness in a global economy through lean manufacturing practices, 6-sigma quality, and supply chain management since the last SME MEP study.^[7, 8, 9, 10, & 11] Manufacturing competitiveness has become such an important issue that professional organizations have sponsored entire sessions with multiple guest speakers on this topic.^[12, 13, 14, 15, & 16]

Historically, the manufacturing industry has relied on a well-educated workforce to adapt to new market threats and opportunities. Accordingly, this study was designed to identify the competencies that are needed by new graduates that are employed in small and mid-sized manufacturers in Illinois.

Objectives of the proposed study

The objectives of the study were to: a) investigate to what extent small and mid-sized Illinois manufacturing companies feel it is important for newly hired manufacturing engineering or technology graduates to possess specified basic personal skills, technical skills and business professional skills, b) compare the skills identified as important in this study with the SME competency gaps listing, and c) use the results of this study as one criteria to revise curriculum and update a laboratory in the IMS Sequence at ISU.

According to Teitelbaum, there is a need to encourage objective appraisals of current manufacturing curriculum and career paths to provide more agile adjustments to inevitable changes required by this dynamic field.^[17] This project was intended to help to address these needs.

Methodology

The population for this study consisted of approximately 3000 companies listed in three categories of the 2004 Illinois Manufacturers Directory. The three categories were plastics products, metal products, and electronics and other electronics equipment. These categories were chosen because of their close alignment with the three options in the IMS Sequence at ISU. The population was made up of small and mid-sized Illinois manufacturers in the three categories. Midsized companies were considered to employ 100 to 500 people and small companies employ less than 100 people.^[18]

There were 403 randomly selected companies chosen from the 2004 Illinois Manufacturers Directory. The sample size was intended to provide data that reflects the total population with a sampling error of +/- 5% at a 95% confidence level. The participants were placed into mid-sized or small company categories based on the number of employees they employ. They were further segmented based on companies that hired IMS alums and those that didn't.

Instrumentation and data collection

The contact person and address listed in the 2004 Illinois Manufacturers Directory for each of the manufacturers selected was used for mailing purposes. A letter explaining the study, an informed consent form, a questionnaire, and a postage paid return envelope were sent to

each participant in the study. Each participant was expected to provide consent in accordance with university policy to be part of the study. The questionnaire contained demographic questions concerning the age of the company, number of manufacturing engineering technology or industrial technology graduates employed, and type of production facility. Three other categories were included in the questionnaire: basic personal skills, technical skills, and business/professional skills. A likert rating scale from 1 to 5 was used for the participant to rate the need for new practitioners to possess certain skills. A “1” was a low need and a “5” a high need.

The basic personal skills category included the nine items. The employers were asked to what extent they felt it was important for newly hired manufacturing engineering or technology graduates to possess the following basic personal skills:

Oral communication skills

Written communication skills

Computer skills

The ability to work effectively in teams

The ability to solve technical problems

The ability to anticipate or plan for the unexpected (urgency)

The ability or motivation to know what’s happening around them (perception)

Leadership and willingness to take initiative

A willingness to learn and improve their knowledge and skills.

Additionally, six items were included in the technical skills section. These items were formulated based on the learning outcomes that had been established for the assessment process used by the IMS Sequence at ISU. The employers were asked to rate the following technical skills with regard to importance:

The ability to interpret and apply basic concepts of materials science such as strength of materials, structural properties, conductivity, and mechanical properties. Perform various non-destructive and destructive materials testing procedures.

The ability to analyze and apply basic electricity and electronic principles within the various manufacturing environments and applications such as industrial robots, controls, and other such systems.

The ability to monitor and control manufacturing processes or other industrial systems.

The ability to select appropriate manufacturing processes for product production applications such as forming, molding, separating, conditioning, joining, and finishing.

The ability to utilize 2-D and 3-D computer-aided design systems to create drawings and models for products, machines, jigs, fixtures, and other mechanical devices used in manufacturing environments.

The ability to read and interpret manufacturing documentation such as blue prints, technical drawings and diagrams, production plans, tooling plans, quality plans, and safety plans.

The business/professional skills section consisted of seven items. The employers were asked to rate the following technical skills with regard to importance:

- An understanding of how to manage projects.
- An understanding of lean manufacturing.
- An understanding of ergonomics.
- An understanding of quality systems.
- An understanding of statistics and probability.
- An understanding of supply chain management.
- An understanding of global economics.

The questionnaire was sent to each of the manufacturers in the study. They were given approximately three weeks to respond. Follow up phone calls were done on those companies who did not respond to the mailed survey.

Findings and Modifications

The mean average of each of the items that the respondents rated in the basic personal skills section was above a 4, which indicated a high rating (5 being the highest). Communication skills (oral, written and computer) were all rated very high. This corresponded with the SME competency listing which includes communication skills. The SME listing also includes personal attributes and team work. Accordingly, this study showed that the employers rated the ability to work effectively in teams as the highest ranking (mean average of 4.56). A willingness to learn and improve their knowledge and skills had the next highest rating (4.41), followed by the ability to solve technical problems (4.31). Leadership was also rated quite high with a mean average of 4.21.

The mean averages in the technical skills area varied from the basic personal skills section. The respondents rated being able to read and interpret manufacturing documentation the highest at 4.44. This is one item that isn't part of the list of SME competencies, or at least does not appear directly as a competency gap in their listing. The ability to monitor and control manufacturing processes or other industrial systems was rated next highest with a mean of 3.83. This was followed by the ability to select appropriate manufacturing processes for product production. Again this is somewhat similar to the SME listing of competencies. They list manufacturing principles and processes as two competency gaps.

The mean averages varied from 2.92 to 4.23 in the business and professional skills section. Global economics was rated the lowest by the employers at 2.92. This was a little surprising, given how many companies operate globally today. Manage projects was rated the highest in this section by the respondents, followed by quality systems next. The mean averages were 4.23 and 4.21 respectively. This coincides quite well with the SME listing which has project management and quality as two important competency gaps.

The results of this study are only one criteria used in the development of a high end, integrated manufacturing laboratory for the Department of Technology. Tours of companies and similar lead educational institutions, visits at trade shows and consultation with an advisory board supported these findings. Consequently, as part of the new IMS laboratory at ISU 12 similarly equipped work stations are being planned with machine tending, assembly and inspection capabilities. The work stations are intended to be moveable to provide flexibility.

Two conveyors will run lengthwise along the side of the workstations to facilitate larger scale integration. Figure one shows an example of the layout of the future integrated manufacturing laboratory. Courses from the freshman level to the senior level will use the new facility. Eight courses in the present curriculum will be impacted by this laboratory. A technical advisory panel has been formed consisting of professionals working in automation and integration related companies. The purpose of the panel is to provide guidance and expertise with regard to the curriculum development of these courses and the finalization of the ordering of hardware and software for the integrated manufacturing laboratory.

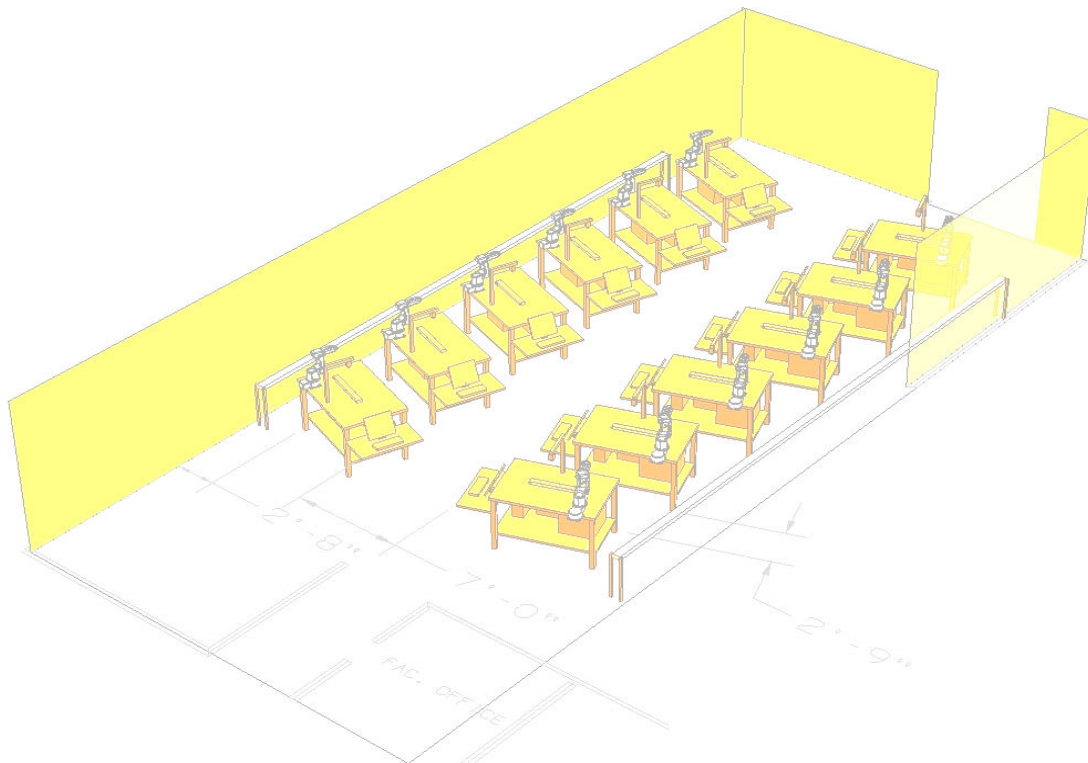


Figure 1. A rough draft model of the new integrated manufacturing laboratory at ISU.

Having 12 workstations in the new facility will allow for class sizes to go as high as 24 students. The facilities will have the capacity to allow two students to work on each station when the class is at maximum capacity. Each workstation will have a conveyor, vision camera, robot manipulator, robot controller, PC components, PLC, radio frequency identification (RFID), and human machine interface (HMI).

Twelve similarly equipped workstations will increase the hands-on time with the stations. This is an important criterion because of the hands-on component of the curriculum. The workstations may be configured to simulate various activities such as machine tending, assembly, inspection and palletizing. The laboratory activities may start with canned programs/setups, with or without bugs. Two backbone conveyors along the wall will facilitate larger scale integration. All the workstation components will be moveable to increase flexibility.

Summary

The results of the study are being used as one factor in the modification of curriculum and instruction and launch of a major capital equipment initiative to renovate an existing laboratory with high technology automation hardware and software. A 1.2 million dollar donation from a company in Illinois will be used to pay an architect to provide a renovation proposal for a lab, renovate the current laboratory facilities, and purchase some of the equipment needed. The study also provided additional support for an equipment grant proposal that was submitted in the fall 2004 semester.

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Biographical Information

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Ken Stier is a professor in the Department of Technology at Illinois State University and sequence coordinator for the Integrated Manufacturing Systems Sequence. He has twenty four years of teaching experience in higher education and worked in industry prior to that.