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A role delineation study for the SME

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A ROLE DELINEATION STUDY FOR

THE SME/AME/SHINGO LEAN MANUFACTURING

CERTIFICATION PROGRAM

By

Hiral A. Shah, CEI, CEM, CAPM

Dissertation

Submitted to the College of Technology

Eastern Michigan University

in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY IN TECHNOLOGY

Area of Concentration: Engineering Management

Dissertation Committee:

Tracy Tillman, Ph.D., Chair

Bob Lahidji, Ph.D.

Philip Cardon, Ph.D.

Teresa Hall, Ph.D.

Pamela Smith, Ph.D.

December, 2007

Ypsilanti, Michigan

DEDICATION

To my mentor, parents, brother,

family (CBS and Taramandal), friends, and all my well wishers.

To the 24 Jain tirthankars for bestowing me with precious principles of Ahimsa
(Non-violence in speech, thought and action), Anekantvad (Multiplicity of Reality),
and Aparigrah (non-attachment to temporal possessions).

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ABSTRACT

The purpose of this research was to perform a role delineation study to validate and prioritize the competency areas included in the body of knowledge developed by SME/AME/Shingo for their three levels of certification examinations in lean manufacturing. A modified Delphi technique was used to gather data and describe what experts in the field consider important for candidates to know and become certified in the discipline of lean manufacturing. Seventy-six Delphi panel experts were selected to serve on the Delphi panel, based on their experience, expertise, and commitment. The study incorporated a Web-based pre-Delphi study followed by three rounds of Delphi questionnaire iterations in both mail and electronic format. A hybrid quantitative and qualitative research design was used for this study in which the Delphi experts were asked to rate the importance of competency areas for testing at each level of lean certification using a 5-point Likert scale and provide additional comments. A convergence of opinion on the competency areas obtained from the Delphi study provided a basis for validating the body of knowledge. A combined grand average of the mean rating of importance and yes percent rating for inclusion was utilized to determine the number of items to be included under each major domain for the Bronze, Silver, and Gold levels of lean certification examinations. The results of the study indicated a need for modifications in the body of knowledge, change in percentage of importance to five major domains under each certification level,

and inclusion of a few additional competency areas.

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CHAPTER I. INTRODUCTION

Introduction

This dissertation research presents a role delineation study to identify and validate the competency areas to be included in the body of knowledge developed by SME/AME/Shingo for their three levels of certification examinations in lean manufacturing.

This introductory chapter will focus on the problem statement, the significance of the problem, objective of my research, research questions, delimitations, limitations, and assumptions of my research. Definitions of some of the special terms used in this project are also provided. Chapters II and III of this dissertation will present a review of literature related to the problem and research design and specific methodology to be followed for this study. The study concludes with Chapter IV, covering data collection and analysis, and Chapter V, regarding results, conclusions, and recommendations.

Statement of the Problem

Prior to this dissertation research, a role delineation study had not been conducted for identifying and validating the competency areas established for creating the examinations used for the SME/AME/Shingo lean manufacturing certification program.

Nature and Significance of the Problem

With recent advances and intense competition in the field of manufacturing, there is a great need to educate and employ qualified professionals in manufacturing. Due to the combination of increased automation

and greater productivity, manufacturers have adopted new management techniques that require more sophisticated, qualified, and adapted workers. These advances in manufacturing have led to an increased expectation of the skill levels of employees by their employers as compared to an earlier era. (Clough, 2005)

According to Womack (2002), lean business and manufacturing practices, along with high quality, are expected to save U.S. industry in the face of intense competition among manufacturing companies. In order to address the issue of identifying and employing skilled employees, certification in manufacturing by a third party can help to show that an individual has kept up with new developments in the field. Certification also provides individuals with a documented credential of proficiency in their profession. Moreover, companies recognize the value of certification, as certification gives an individual a sense of personal achievement, greater confidence, and a competitive edge over other individuals who are not certified (Frost, 1998).

It is critical, especially now, that practicing engineers and managers--and students of manufacturing, engineering, and management--understand the principles and practical applications of lean manufacturing (McGinnis, 2002). A variety of education, training, and certificate programs are offered by many institutions as well as organizations that focus on principles of lean manufacturing, such as value stream mapping, principles of cellular/flow manufacturing, the 5S system, lean enterprise culture, quick changeover/setup reduction, and total productive maintenance (TPM), and some require

implementation of a project in lean manufacturing. Such certificate programs often require only training and project work by the candidate, but not a validated examination to test their competency in lean manufacturing.

Hogan (2005) emphasized the need for lean certification based on a survey of more than 1100 manufacturing industry respondents. Eighty-three percent of the participants in the survey mentioned that it was either critical or very important to develop an industry standard for lean certification. Hogan (2005) also suggested that the body of knowledge for each level of lean certification should be periodically evaluated and updated to ensure continuous improvement, and to make the certification nationally-normed, regardless of location. Moreover, a well-constructed job analysis study is an essential foundation for a valid, reliable, and legally defensible professional certification program (Wehrle, 2005). The following is also stated in the Joint Standards for Educational and Psychological Testing (AERA, APA, and NCME, 1999) standard 14.14:

> The content domain to be covered by a credentialing test should be defined clearly and justified in terms of importance of the content for the credential-worthy performance in an occupation or profession. A rationale should be provided to support a claim that the knowledge or skills being assessed are required for credential-worthy performance in an occupation and are consistent with the purpose for which the licensing or certification program was instituted. (p. 161)

A certification program should be based on valid criteria and should evaluate and document an individual's knowledge, skills, and capabilities in a specific professional discipline. Shingo and AME have identified the need for a professional certification program in lean manufacturing, and have requested SME to develop a new certification based on the Shingo criteria for excellence in manufacturing (Shingo, 2004). Hence, such a new professional certification program in lean manufacturing was being developed by a consortium composed of the Society of Manufacturing Engineers (SME), the Shingo Prize for Excellence in Manufacturing (Shingo), and the Association for Manufacturing Excellence (AME). To begin this process, SME developed a prototype body of knowledge (BOK) for the discipline of lean manufacturing. This BOK was developed to delineate the range and degree of emphasis of content areas that form the framework for the examination(s) to be taken by lean manufacturing certification candidates.

Such a certification examination developed in the field of lean manufacturing establishes a direct and identifiable link between the test questions in the exam and competency areas in the BOK to support the inference that the scores achieved on the exam are content-valid (Wehrle, 2005). Hence, the lean certification program needs a body of knowledge that is validated through experts in the field of lean manufacturing via this role delineation study.

Objective of the Research

The purpose of this research was to gather data for a role delineation study to validate and prioritize the competency areas to be included in the BOK for the SME/AME/Shingo lean manufacturing certification program.

Research Questions

The following research questions were answered at the conclusion of this research project:

1. What content/competency areas do the experts think should be included in the three lean manufacturing certification examinations?

2. What percentage of importance should be allocated to each major category (domain) in the body of knowledge?

3. How many items should be present under each domain of the body of knowledge on the exam?

4. Are there differences in the body of knowledge delineated in SME's prototype BOK and that found through this study?

Delimitations

The results of this study will be specifically applicable to the SME/AME/Shingo lean certification program. However, the results may also be useful to universities and other training centers in the United States for development of lean manufacturing program curricula.

Assumptions

It was assumed that the panel of experts in the Delphi study would be

1. Appropriately knowledgeable in lean manufacturing and honest and non-biased in their responses.

2. Representative of the population at an expert level in terms of geographical location, educational background of experts, and type of industry.

Limitations

The following limitations were evident after the study was conducted:

1. The pre-Delphi survey had a very low response rate. Only 138 individuals responded, from a pool of 6000 who were contacted by email. However, the pre-Delphi survey was meant to be a screening tool, not a descriptive survey--its purpose was to identify experts from among the population who could serve on the Delphi panel, rather than to seek general representation of the overall population. That objective was achieved, as all 76 members on the Delphi panel held a high level of expertise.

2. The panel of experts' demographic information showed that 17% of them resided internationally. It should be noted that the experts in the study are from 6 different countries, including the United States. The study tried to include representation from international experts, but there may be other experts from other countries whose opinions are not recorded.

3. As the Delphi panel was limited to 76 experts, representing a larger population of experts in the discipline of lean manufacturing worldwide, it is

possible that there may be other experts who would not agree to the competency areas included in the lean body of knowledge.

4. An attempt was made to administer the Delphi questionnaire in a clear and understandable manner. It may be possible that there was a discrepancy on the definition of some of the competency areas included on the questionnaire.

5. There is a possibility that the importance of higher level competency areas may have been rated artificially high because of the level of expertise and years of experience of the members of the Delphi panel.

Definition of Terms

AME. The Association for Manufacturing Excellence (AME) is a not- for-profit, practitioner-based organization dedicated to cultivating understanding, analysis, and exchange of productivity methods and their successful application in the pursuit of excellence (extracted: http://www.ame.org).

Certification. A program of professional documentation and recognition of an individual's manufacturing-related knowledge, skills, and capabilities (extracted: http://www.sme.org).

Competency. The knowledge, skill, and ability in a specific subject area or skill set to perform a specific set of related tasks successfully to meet a specified standard.

Delphi technique. The process of collecting and distilling knowledge from a group of experts by means of a series of questionnaires interspersed with controlled opinion feedback. Typically, the Delphi procedure begins with

identifying and selecting the individuals who will compose the Delphi panel. The first-round questionnaire in which the Delphi panelists are subject to anonymous brainstorming is unstructured and open-ended. In the second round, results from the first round are provided to the experts to consider, to rank and/or rate, and to comment upon. Similarly, a third round and other subsequent rounds are conducted with intent to achieve consensus of responses from the panel members. The Delphi procedure ends once consensus and/or stability is reached. (Murry & Hammons, 1995)

Lean manufacturing. An overall methodology that seeks to minimize the resources required for production by eliminating waste (non-value added activities) that inflates costs, lead times, and inventory requirements, and by emphasizing the use of preventive maintenance, quality improvement programs, pull systems, and flexible work forces and production facilities.

Role delineation study. A method used to identify the performance domains and associated tasks, knowledge, and/or skills relating to the purpose of the credential and provide a basis for validation for the credentialing examination (NOCA, 2005).

Shingo. The Shingo Prize for Excellence in Manufacturing was established in 1988 to promote awareness of lean manufacturing concepts and recognize companies in the United States, Canada, and Mexico that achieve world-class manufacturing status. The Shingo Prize philosophy is that world-class business performance may be achieved through focused improvements in core manufacturing and business processes (extracted: http://www.shingoprize.org).

SME. The Society of Manufacturing Engineers is the professional society that supports manufacturing education and promotes an increased awareness of manufacturing engineering by keeping manufacturing professionals up to date on leading trends and technologies (extracted: http://www.sme.org).

Summary

This chapter provided a short introduction to the nature of today's manufacturing industry and described a need for this study to validate the body of knowledge for the SME/AME/Shingo lean manufacturing certification program. In the next chapter, a review of related literature will provide more in-depth information about lean manufacturing, certification exam development practices, and Delphi research methods.

CHAPTER II. BACKGROUND AND REVIEW OF LITERATURE

Introduction

This chapter provides a review of relevant literature regarding the background of lean manufacturing, a content analysis of books on lean manufacturing, best practices in certification development and role delineation studies, the Delphi technique, and the SME/AME/Shingo lean manufacturing certification program.

Background Information

The Society of Manufacturing Engineers (SME) is the world's leading professional society supporting manufacturing education (extracted: http://www.sme.org/cgi-bin/abouthtml.pl?/html/about.htm&&&SME&). It currently offers the following certifications:

1. Certified Manufacturing Technologist (CMfgT) – focuses on the fundamentals of manufacturing.

2. Certified Manufacturing Engineer (CMfgE) – recognizes comprehensive knowledge of manufacturing processes and practices.

3. Certified Engineering Manager (CEM) – documents skills and understanding of business processes, external enterprise influences, customer focus, teamwork, and responsibilities.

4. Certified Enterprise Integrator (CEI) – recognizes proficiency in leading cross-functional initiatives throughout a company's extended supply chain. (extracted: http://www.sme.org)

These certifications are valid for three years. Candidates must be recertified to sustain their certification by earning a certain number of continuing education credits and paying recertification fees per SME guidelines.

In 2004 there were many lean certificate programs offered by different institutions, but there was no industry-wide recognized certification program in existence. The need to develop a lean certification program was based on a survey conducted by SME in the year 2004 on more than 1100 manufacturing industry respondents. The results of the survey indicated that there was a lack of a true consistent standard to align various lean practices existing in the market.

The Society of Manufacturing Engineers (SME) initially planned to develop a lean certification program in partnership with two other organizations: the Shingo Prize for Excellence in Manufacturing (Shingo) and another non-disclosed organization. Based on previous experience with the Certified Engineering Manager (CEM) certification program, Tillman (2003) took an initiative to create a framework for the Lean certification program. As the work progressed, the Association for Manufacturing Excellence (AME) became actively involved as the third party, rather than IIE.

The three professional organizations - SME, AME, and Shingo - worked together to create a rigorous lean certification program as a benchmark of competence in lean practice. To begin the process, these organizations developed a body of knowledge (BOK) for the discipline of lean manufacturing. This BOK delineates the range of content areas to be covered in the examination(s) that will be taken by lean manufacturing certification candidates.

In order to understand the areas included in the body of knowledge, it is essential to know the focus and evolution of the lean manufacturing discipline.

Lean Manufacturing

The American Society for Quality (ASQ) mentions that the initiative of lean manufacturing is focused on eliminating all waste in manufacturing processes. Principles of lean include zero waiting time, zero inventory, scheduling (internal customer pull instead of push system), batch to flow (cut batch sizes), line balancing, and cutting actual process times. Hence, lean production is an important feature of modern manufacturing, but it can apply to any business process. Trombly (2002) mentioned, "Done properly, lean production can lead to improvements in efficiency, quality and customer service, and drive down the costs of doing business" (p. 54).

Various components required in lean manufacturing are depicted in the literature. Kincaid (2004) stated the following steps that are involved in implementation of lean techniques: value stream mapping, 5-S, visual process control, metrics and accountability, Kaizen, cross-training, and error-proofing. Kincaid also mentioned that the improvement programs working together can make a safer, more productive and efficient workplace that is better equipped to compete in the global economy. "Lean" business and manufacturing practices, along with high quality, are what are expected to save U.S. industry in the face of this competition (Womack, 2002).

History of Lean Manufacturing

According to Jordan and Michel (2001), "Lean manufacturing is part of a progression that started with the industrial revolution in England. The progression started with Abraham Dooby's *[sic]* invention of steel-making processes" (p. 11). After a series of inventions following the invention of the steam engine by James Watt in 1769, new ways were developed to make things with the help of machinery. The machine tool industry led to the development of sewing machines, typewriters, bicycles, and, eventually, automobiles.

Before World War I, the auto industry was based on a craft production system. As stated by Womack, Jones, and Roos (1990), the craft production system had the following characteristics:

(a) A work force that was highly skilled in design, machine, operations, and fitting.

(b) Organizations that were extremely decentralized, although concentrated within a single city. Most parts and much of the vehicle's design came from small machine shops. The system was coordinated by an owner/entrepreneur in direct contact with everyone involved – customers, employers, and suppliers.

(c) The use of general-purpose machine tools to perform drilling, grinding, and other operations on metal and wood.

(d) A very low production volume – 1,000 or fewer automobiles a year, only a few of which (fifty or fewer) were built to the same design. And even

among those fifty, no two were exactly alike since craft techniques

inherently produced variations. (p. 24)

The major disadvantages of craft production were:

(a) High production costs, which did not drop with volume; hence, only the rich

could afford these cars.

(b) Issues with consistency, quality, and reliability of the car as each car made

was more or less different from the others.

(c) Lack of innovation in technological advancement and improvement activities

as the individual craftsmen did not have the resources to pursue fundamental

innovations (Womack, Jones, & Roos, 1990).

During this time, Henry Ford found a way to overcome the drawbacks and

issues related to craft production. Ford manufactured the Model T in 1908 in

order to address the problems inherent with craft production. The key features of

this car were ease in manufacturing and assembly, and interchangeability of

parts. Ford used the same gauging system for every part throughout the

production operations to achieve interchangeability. This was the first step in the

auto industry to progress to mass production by using the assembly line after

World War I. It also led to the standardization of parts and innovations in designs

in the automobile industry. There was a reduction in cycle time from hours in

1908 to minutes in 1913. Thus, Ford's principle innovations during this period

were (a) interchangeability and ease of assembly of parts, (b) reduction of

actions required of each worker, and (c) the moving assembly line (Dennis, 2002,

p. 3).

Moreover, mass production required narrowly skilled professionals to design products made by unskilled or semiskilled workers tending expensive, single-purpose machines (Womack, Jones, & Roos, 1990, p. 13). Hence, mass production was successful because it could take advantage of economies of scale. As the cost of manufacturing the cars was reduced, customer demand increased. The volumes of production were so large that manufacturers could use specialized machines with hard tooling for a single manufacturing operation (Jordan & Michel, 2001). Jordan and Michel also mentioned, "The Rouge plant before World War II was almost totally integrated. Ford produced all the parts it needed in its own facilities. Ford had built 15 million Model-T cars by 1928 when it introduced the Model A" (p. 13).

Due to competition, the prices of cars decreased, markets grew, and mass production was adopted all over the world. Despite the variety of advantages obtained through mass production, there was a growing dysfunction among the workers, quality of production, engineers, and so on. The workers were finding their jobs to be monotonous. The defect rate was increasing, and the parts were not in accordance with the standards. There was a buildup of large amounts of work-in-progress and finished goods inventories even though there was no customer to buy. Due to the complexity of production, specialized engineers were employed, which created lack of coordination between the engineers. Jordan and Michel (2001) presented the following:

Then came World War II, which devastated very nearly all the world's industrial capacity and capabilities outside the Western Hemisphere. In

1946, automobile companies turned out millions of cars to meet pent-up post-war demand. Japan's industrial capabilities literally had been flattened by the summer of 1945. They were at the bottom of the economic spiral, with markets too small to generate the capital they would need to build the huge factories the mass production paradigm demanded. (p. 13)

Eiji Toyoda, a young Japanese engineer, visited Ford's Rouge plant in Detroit in 1950. Eiji Toyoda's family had founded the Toyota Motor Company in 1937. After World War II, Japan and the Toyota Motor Company were in crisis. There was a collapse in sales at Toyota at the end of 1949. After thirteen years of effort, Toyota had produced a total of only 2,685 automobiles, compared to the 7,000 automobiles produced by Ford's Rouge plant in a single day (Womack, Jones, & Roos, 1990). Eiji Toyoda studied the Ford facility and production process very carefully and found inherent defects in Ford's production system. After returning to Japan, Eiji Toyoda and his production genius, Taiichi Ohno, came to a conclusion that Ford's mass production system could not be implemented in Japan due to its small market and other reasons. Liker (2004) stated:

Toyota did not have the luxury of creating waste, it lacked warehouse and factory space and money, and it didn't produce large volumes of just one type of vehicle. But it determined it could use Ford's original idea of continuous material flow to develop a system of one-piece flow that flexibly changed according to customer demand and was efficient at the

same time. Flexibility required marshaling the ingenuity of the workers to continually improve processes. (p. 22)

Hence, the Toyota Motor Company applied the principles of jidoka (built in quality or mistake-proofing) and one-piece flow, and as years passed they developed what is known as the Toyota Production System (TPS), or lean production. TPS had borrowed some of its ideas, such as the concept of the pull system from the United States. Toyota also used the kanban method (signaling technique) in its pull system along with just-in-time (JIT) and jidoka. Thus, TPS or lean production was developed to meet the challenges faced by Toyota. TPS further evolved by adopting the quality principles of Edwards Deming, which was termed as Kaizen by the Japanese, meaning continuous improvement. As Liker (2001) observed, "Toyota had learned decades earlier through focusing on speed in the supply chain: shortening lead time by eliminating waste in step of a process leads to best quality and lowest cost, while improving safety and morale" (p. 25).

Literature Related to the Problem

In order to understand the different types of credentials related to the problem under study, it becomes important to know the differences and similarities between them.

Certificate, Certification, Licensure, Accreditation

Credentials such as certificate, license, or diploma recognize fulfillment of a pre-established level of performance in some domain of knowledge or activity

(American Educational Research Association, American Psychological Association, and National Measurement in Education, 1999). Credentials may be in the form of certification, licensure, or accreditation. However, there are significant differences as well as similarities between accreditation, licensure, certificate, and certification programs. Accreditation and certification are regulated and administered by professional associations, while licensure is administered by a political or government body. Certification is a voluntary process for individuals to demonstrate their level of knowledge and skill in a subject area. On the other hand, licensing is an authorization or legal permission to practice an occupation or profession. Wiley (1995) provided a comparison of accreditation, certification, and licensure programs as depicted in Table 1 (p. 19).

There are numerous certificate programs available in the market and some certification programs as well. Certificate and certification programs also vary significantly. A certificate program is a training program on a topic for which participants receive a certificate after attendance and/or completion of the coursework or successful demonstration of attainment of the course objectives (National Organization for Competency Assurance, 2005). These programs are not held to the objective standards required of the other types of credentialing programs, and a certification is a credential that is not usually just automatically granted at the completion of a training program.

Table 1.

Comparisons of Accreditation, Certification, and Licensure

Factors	Accreditation	Certification	Licensure
Regulation/ Administration	Not-for-profit organizations.	A certification institute/agency or a professional, trade or educational association.	A political or government body.
Enforcement	Voluntary at the institutional level (institutions can offer nonaccredited programs).	Voluntary at the individual level (individuals can practice without certification).	Involuntary or mandatory at the individual and occupational levels (individuals cannot practice without a license).
Focus	Policing educational and other programs.	Enhancing a profession.	Policing a profession or occupation.
Goal	To evaluate instructional programs.	To measure the practitioner's competence.	To restrict entry of incompetent persons and practitioners.
Strengths	Ensures quality instructional programs.	Promotes basic competencies among professionals.	Ensures quality of services rendered.
	Encourages interaction between professionals associations and colleges and universities.	Codifies the body of knowledge.	Protects the consumer and client from substandard services.
Weaknesses	Barriers to curricula variability.	Comparatively small numbers of certified professionals.	Labor under utilization.
	No hard evidence that graduates of accredited programs are better prepared.	Little evidence of value added by certified professionals.	Expensive professional services.

Note. From "Reexamining Professional Certification in Human Resource Management," by C. Wiley, 1995, *Human Resource Management, 34*(2), p. 272.

Typically, there are three kinds of certificate programs (NOCA, 2005):

1. Knowledge-based certificate – recognizes a narrow scope of specialized knowledge and is issued after the individual passes an assessment instrument.

2. Curriculum-based certificate – limited to the course content and therefore may not be completely representative of occupational practice and is issued after an individual completes a course or series of courses and passes an assessment instrument.

3. Certificate of attendance or participation – issued after an individual attends or participates in a particular meeting or course and is not a credential. Usually, no knowledge is assessed prior to issuing this type of certificate (p. 6).

The fundamental differences between certificate and certification programs are explained in Table 2 (p. 21). Certification benefits the organizations in such a way that certified professionals can be expected to demonstrate better performance because standardizing measure of competence is available regarding the employee's knowledge, skills, and abilities. The certification process also benefits a profession by establishing minimum competencies that are necessary for an acceptable job performance via a codified body of knowledge (Wiley, 1995). In order to establish credibility and maintain sustainability, a certification program must follow recognized norms and standards.

Table 2.

Differences between Certification and Certificate Programs

Certification	Certificate
1. Results from an assessment process that recognizes an individual's knowledge, skills and competency in a particular specialty.	Results from an educational process.
2. Typically requires professional experience.	For newcomers and experienced professionals.
3. Awarded by a third-party, standard-setting organization, typically not for profit.	Awarded by educational programs or institutions often for-profit.
4. Indicates mastery/competency as measured against a defensible set of standards, usually by application or exam.	Indicates completion of a course or series of courses with a specific focus (different than a degree granting program).
5. Standards set through a defensible, industry-wide process (job analysis/role delineation) that results in an outline of required knowledge and skills.	Course content determined by the specific provider or institution, not standardized.
6. Typically results in credentials to be listed after ones name.	Usually listed on a resume detailing education.
7. Has ongoing requirements in order to maintain; holder must demonstrate he/she continues to meet requirements.	Demonstrates knowledge of course content at the end of a set period in time.

Note. From American Legal Nurse Consultant Certification Board. Extracted May 4, 2006 from

http://www.aalnc.org/lncc/about/certificate.cfm

Lean Certification

The Northwest Wisconsin Manufacturing Outreach Center partnered with the Wisconsin Technical College System to offer a lean certification, which focuses on principles of lean manufacturing such as value stream mapping, principles of cellular/flow manufacturing, the 5S system, lean enterprise culture, quick changeover/setup reduction, total productive maintenance (TPM), and implementation of a project in lean manufacturing. This certification requires only training and project work by the candidate, rather than an examination to test their knowledge and skills in lean manufacturing. The definitive need to create a credentialing process for lean manufacturing was based on a survey conducted by the Society of Manufacturing Engineers (SME) in 2005 with more than 1100 industry respondents. The findings of this research indicated that 77 percent of these respondents were very likely to pursue such a certification in lean, while 83 percent stated that lean certification was critical, very important, or important. Moreover, 60 percent of those surveyed stated that key lean leaders at their supplier companies should earn lean manufacturing certification (Hutchins, 2005).

To initiate this process, four levels of lean certification were initially planned (SME, 2006), namely:

1. Level 1: Knowledge Certificate – to measure the knowledge of basic principles, concepts, and tools of lean as applied to factory, office and service, team facilitation, and appropriate measurement of results.

2. Level 2: Bronze Certification – to measure the capability of candidates in applying lean principles and tools to drive improvements and show measurable results.

3. Level 3: Silver Certification – to measure the capability of lean practitioners in applying lean principles and tools to drive improvements and show measurable results plus orchestrate the transformation of a complete value stream.

4. Level 4: Gold Certification – this is the highest level focused on evaluating the practitioner's strategically focused knowledge and solid understanding of all aspects of lean transformation across the entire enterprise.

Levels 1 and 2 have been combined into a single Bronze certification. Each level of certification requires the applicant to pass a written examination consisting of approximately 150 questions within a three-hour time limit. According to SME (2006), "Unlike other programs in the market today, lean certification is awarded based on experience, education, and mentoring – and it must be renewed." The experiential requirement for this certification is demonstrated through portfolio evaluation.

To begin the certification development process, the body of knowledge (BOK) for the lean certification has been defined by the consortium of SME, AME, Shingo and a panel of experts. This BOK currently in use by SME is shown in Appendix A. However, according to the guidelines and standards for developing professional certification examination, a validation study of the BOK is essential (AERA, APA, and NCME, 1999). Guidelines and standards for

developing professional certification examinations have been established by psychometric experts and mandated by professional testing and test oversight organizations, such as the Council of Engineering Specialty Boards (CESB), National Organization of Competency Assurance (NOCA), American Psychological Association (APA), National Council on Measurement in Education (NCME), and others (Tillman, 2005).

Professional Standards and

Best Practices for Certification Examination Development

Certification standards and psychometric principles help to ensure that a certification is valid, reliable, of crucial importance, and legally defensible. Various organizations such as the National Occupational Competency Testing Institute (NOCTI), Chauncey Group, the National Commission for Certification Agencies (NCCA), and the National Organization for Competency Assurance (NOCA) provide standards and guidelines for certification. The American Psychological Association (APA), American Educational Research Association (AERA), and the National Council on Measurement in Education (NCME) provide standards for test development that are typically used by organizations involved in certification testing (Rowe, 2001). The Council of Engineering and Scientific Specialty Boards (CESB) also provides guidelines for engineering and related specialty certification programs. In order to achieve CESB (2006) recognition, the following guidelines must be met:

The certifying body must have developed a detailed document specifying

the "body of knowledge" or "minimum level of skills and knowledge"

required by a practitioner in the specialty area. Evidence must be

presented that the body of knowledge document bas been developed and

subjected to critique by practicing professionals in the field. The

document must be reviewed and updated as necessary to maintain

currency with the state-of-the art no less frequently than once every five

years. (p. 4)

CESB (2006) also requires the certification body to publish a document as

a public disclosure that includes (a) the certification responsibilities of the

certifying body; (b) activities of the certifying body not related to certification; (c)

general descriptions of the procedures used in test construction and validation,

test administration, and reporting of test results; (d) comprehensive summary or

outline of the information, knowledge, or functions covered by any examination

which may be required; and (e) a summary of certification activities, including

number of applicants, number certified, and number recertified on annual basis.

The National Commission for Certifying Agencies (NCCA) is the

accrediting body for the National Organization for Competency Assurance

(NCCA). NCCA uses a peer review process to accredit certification

organizations that comply with its standards. NCCA standards (2004) require

that the certification program publish a description of the assessment instruments

used to make certification decisions as well as the research methods used to

ensure that the assessment instruments are valid (p. 8). NCCA (2004) standard 10 states:

> The certification program must analyze, define, and publish performance domains and tasks related to the purpose of the credential, and the knowledge and/or skill associated with the performance domains and tasks, and use them to develop specifications for the assessment instruments. (p. 10)

The essential elements used to fulfill these standards include (a) a job/practice analysis to delineate performance domains and tasks, associated knowledge and/or skills, and sets of content/item specifications to be used as the basis for developing each type of assessment instrument (e.g. multiple-choice, essay) and (b) a published report that links the job/practice analysis to specifications for the assessment instruments (NCCA, 2004).

The joint standards for educational and psychological testing (AERA, APA, and NCME, 1999) state the following standards for testing in employment and credentialing:

> *Standard 14.10.* When evidence of validity based on test content is presented, the rationale for defining and describing a specific job content domain in a particular way (e.g., in terms of tasks to be performed or knowledge, skills, abilities, or other personal characteristics) should be stated clearly. (p. 160)
>
> *Standard 14.14.* The content domain to be covered by a credentialing test should be defined clearly and justified in terms of importance of the

content for the credential-worthy performance in an occupation or

profession. A rationale should be provided to support a claim that the

knowledge or skills being assessed are required for credential-worthy

performance in an occupation and are consistent with the purpose for

which the licensing or certification program was instituted. (p. 161)

These standards also require that the level of performance required for passing a

credentialing test should depend on the knowledge and skills necessary for

acceptable performance in the profession and should not be adjusted to regulate

the number or proportion of persons passing the test (AERA, APA, and NCME,

1999, p. 162). The Uniform Guidelines on Employee Selection Procedures

developed by the United States government's Equal Employment Opportunity

Commission have also published standards that require validation of employment

tests in instances of adverse impact.

Best Practices for Certification Exam Development

AERA, APA, and NCME (1999) recommend the following procedure to

develop a licensing and employment test:

(a) Determine a statement of purpose(s), and the construct or content domain to

consider and extend it into a framework that describes the scope of the construct

to be measured.

(b) Guide the delineation of the test framework by an analysis of job

requirements.

(c) Establish test specifications that include implicitly whether the test scores will

be primarily norm-referenced or criterion-referenced.

(d) Pre-Delphi test of the items to ascertain the quality and psychometric

properties of the items.

(e) Assemble items into a test and facilitate meaning score interpretation.

The Association of Boards of Certification (2000) recognizes the following

steps: (a) Conduct a job analysis, (b) develop and validate items, (c) develop an

exam, and (d) establish a cut score.

Downing (2006) provided twelve steps as a convenient organizational

framework for collecting and reporting all sources of validity evidence for a

testing program along with the corresponding standards developed by AERA,

APA, and NCME (1999). Table 3 (p. 29) provides detailed information about the

test development process. These steps provide a systematic process for

creating effective testing programs of all types.

Table 3. *Twelve Steps for Effective Test Development*

Steps	Example Test Development Tasks	Example Related Standards (AERA, APA, NCME, 1999)
1. Overall plan	Systematic guidance for all test development activities: construct; desired test interpretations; test format(s); major sources of validity evidence; clear purpose; desired inferences; psychometric model; timelines; security; quality control	Standard 1.1 Standard 3.2 Standard 3.9
2. Content definition	Sampling plan for domain/universe; various methods related to purpose of assessment; essential source of content-related validity evidence; delineation of construct	Standard 1.6 Standard 3.2 Standard 3.4 Standard 3.11
3. Test specifications	Operational definitions of content; framework for validity evidence related to systematic, defensible sampling of content domain; norm or criterion referenced; desired item characteristics	Standard 1.6 Standard 3.2 Standard 3.3 Standard 3.4 Standard 3.11
4. Item development	Development of effective stimuli; formats; validity evidence related to adherence to evidence-based principles; training of item writers, reviewers, effective item editing; CIV owing to flaws	Standard 3.6 Standard 3.7 Standard 3.17 Standard 7.2 Standard 13.18
5. Test design and assembly	Designing and creating test forms; selecting items for specified test forms; operational sampling by planned blueprint; pre-testing considerations	Standard 3.7 Standard 3.8
6. Test production	Publishing activities; printing or CBT packaging; security issues; validity issues concerned with quality control	N/A
7. Test administration	Validity issues concerned with standardization; ADA issues; proctoring; security issues; timing issues	Standard 3.18 Standard 3.19 Standard 3.20 Standard 3.21
8. Scoring test responses	Validity issues: quality control; key validation; item analysis	Standard 3.6 Standard 3.22
9. Passing scores	Establishing defensible passing scores; relative vs. absolute; validity issues concerning cut scores; comparability of standards: maintaining constancy of score scale (equating, linking)	Standard 4.10 Standard 4.11 Standard 4.19 Standard 4.20 Standard 4.21
10. Reporting test results	Validity issues: accuracy, quality control; timely; meaningful; misuse issues; challenges; retakes	Standard 8.13 Standard 11.6 Standard 11.12 Standard 11.15 Standard 13.19 Standard 15.10 Standard 15.11
11. Item banking	Security issues; usefulness, flexibility; principles for effective item banking	Standard 6.4
12. Test technical report	Systematic, thorough, detailed documentation of validity evidence; 12-step organization; recommendations	Standard 3.1 Standard 6.5

Note. ADA-Americans with Disabilities Act; CBT-Computer-based testing, CIV-construct-irrelevant variance. From "Test Development" by S.M. Downing, 2006. In Haladyna, T.M., & Downing S.M (Eds.), *Handbook of Test Development*, p. 5. Mahwah, NJ: Lawrence Erlbaum.

According to Althouse (2001), the test development process usually involves ten steps, with each step instrumental in ensuring the validity, reliability, defensibility, and security of the examination. These steps include

1. Conducting job and task analysis.

2. Developing the test blueprint.

3. Developing items.

4. Reviewing and validating items.

5. Assembling and delivering beta exams.

6. Analyzing beta exams results.

7. Constructing equivalent exam forms.

8. Establishing the passing score.

9. Administrative/scoring operational exams.

10. Providing ongoing test maintenance. (p. 244)

In addition to these steps, Tillman (1997) recommended a creation of separate certification organization with administrative independence from the parent organization, conducting a market/needs analysis for a new certification before development begins, use of a modified Angoff method to set the passing point, and pretesting the new examination on subjects similar to the population to be tested (p. 113). He also recommended conducting an item analysis to improve or delete items that performed poorly and conducting a new formal study for a major redevelopment (from scratch) of the examination every 3 to 5 years.

The Project Management Institute has offered the Project Management Professional (PMP) certification since 1984 and the Certified Associate in Project

Management (CAPM) certification exam since 2001. The major steps of examination development for the PMI (PMI, 2002) include (a) analyzing the responsibilities of certification candidates; (b) specifying a plan for the test; (c) writing, reviewing, referencing, and validating questions; (d) assembling the examination; and (e) deciding the score required for passing the test.

According to Hall and Tillman (2006), the Society of Manufacturing Engineers' (SME) protocol for exam development and maintenance is as follows:

1. Determine the need for a potential certification exam.

2. Conduct a market survey to validate the need and possible target market for new certification.

3. Conduct a role delineation/task analysis survey via a Delphi study, validated survey, or content specialist panel to determine competencies and job tasks.

4. Develop the body of knowledge based on the task analysis.

5. Finalize exam preparation, establish passing score, and pre-Delphi test the exam using content specialists.

6. Monitor pass rates, exam performance, specifications, overall results, internal consistency reliability, and revision.

7. Statistical analysis, BOK validation, and item review based on content validity, construct validity, and reliability of the exam.

All these sources provide evidence that a role delineation study is an essential step in the exam development process. Such a formal study can help in determining the content and competency areas to be included in the body of

knowledge. Before proceeding toward the development of a body of knowledge, a thorough analysis of literature related to the subject area intended for testing is helpful. Such a content analysis of the literature related to lean manufacturing was conducted to delineate the major topic areas within lean manufacturing, the results of which are in the following section.

Content Analysis of Books on Lean Manufacturing

A content analysis of books on lean manufacturing was performed to create an initial framework and listing a range of competency areas. After reviewing the content areas of twelve books on lean manufacturing, the following results were obtained as shown in Table 4 (p. 33). The list of books used for content analysis is shown in Appendix B. The topic areas covered in these books were categorized into 40 major competency areas, and a frequency analysis was performed to find out what areas of lean manufacturing occurred most frequently in these books. The results shown in Table 4 (p. 33) are arranged in descending order.

The content areas that were frequently discussed in more than 50% of these books were continuous improvement, operational strategies for the lean company, organization structure/management infrastructure/culture, project teams management structure, strategic vision, 5S, and Kaizen. One third of these books also covered topics such as change management, cost of lean change, history of lean manufacturing, implementing pull system, kanban strategies/system, leadership, line balancing, and value stream mapping.

Table 4

Review of Content Analysis Based on Twelve Books in Lean Manufacturing

Content Areas in Lean Manufacturing	No. of Books	Percentage
Continuous improvement	7	58%
Operational strategies for the lean company	7	58%
Organization structure/Management infrastructure/Culture	7	58%
Project teams management structure	7	58%
Strategic vision	7	58%
5S	6	50%
Kaizen	6	50%
Benefits of lean thinking	5	42%
Minimizing waste (categories of waste)	5	42%
Planning and Scheduling	5	42%
Change management	4	33%
Cost of Lean change	4	33%
History of lean manufacturing	4	33%
Implementing pull system	4	33%
Kanban strategies/system	4	33%
Leadership	4	33%
Line balancing	4	33%
Value stream mapping	4	33%
Customer focus	3	25%
Mistake-proofing	3	25%
MRP	3	25%
Performance metrics	3	25%
Six sigma quality	3	25%
Throughput, volume & Takt time	3	25%
Total Productive Maintenance (TPM)	3	25%
Value-added & Non-value added activities	3	25%
Visual Management	3	25%
Enterprise Integration	2	17%
JIT	2	17%
Performance management	2	17%
Rewards & recognition	2	17%
Best practices	1	8%
Decision-making	1	8%
ERP	1	8%
Knowledge management	1	8%
Lean implementation: DMAIC tools	1	8%
Product life cycle management	1	8%
Quality assurance	1	8%
Supply chain management	1	8%
Sustaining lean-long term execution	1	8%

Literature Related to the Research Design

A role delineation/job analysis study is the most highly recommended and extensively used technique to validate the body of knowledge for a certification examination. Nelson (1994, p. 30) stated that although job analysis models vary considerably in methodology, they have a common characteristic of reliance on validation by a representative panel of Subject Matter Experts (SMEs), but there is a lack of consensus in such research. Hall and Tillman (2006) recommended a role delineation study be conducted using a Delphi survey methodology, validated survey, or content specialist panel to determine competencies and job tasks.

Role Delineation Study

NCCA's standards for the accreditation of certification programs (National Organization for Competency Assurance, 2005) defines a job analysis or role delineation study as, "Any of several methods used singly or in combination to identify the performance domains and associated tasks, knowledge, and/or skills relating to the purpose of the credential and providing the basis for validation" (p. 9).

NOCA (2005) defines *role* as, "A more specific or narrower set of knowledge and skills that may be encompassed by the term 'profession' or 'occupation,' and may also be the focus of certification for particular product or service" (p. 9). A role delineation study is commonly administered to practicing professionals through a survey and it asks respondents to rate questions on relevant and important tasks that constitute job performance in the profession.

Role delineation studies for licensure and certification exams are typically

national in scope, may cover a multitude of settings, and usually require a

broader sampling plan (Raymond, 1995). The steps involved in a typical role

delineation study are:

       1. Initial development and evaluation – involves identifying domains, tasks,

knowledge, and skills.

       2. Validation study – conducting a role delineation survey using the

domains and tasks identified in Step 1.

       3. Test specifications – identifying the proportion of questions from each

domain and task for the examination.

A role delineation survey also collects demographic information from the

respondents. This information serves two main purposes. It (a) describes the

respondent sample which helps to evaluate the representativeness of the

sample; and (b) helps in breaking down the data for detail evaluation (Castle,

2005).

Examples of Role Delineation Studies

       Adapted Physical Education National Standards (APENS) conducted a

national role delineation survey in 1992-93 to ensure that the APENS content

would match what adapted physical educators perceived they needed to know to

do their jobs on a daily basis (Davis, 2001). Four major educational domains and

17 sub-content areas were predetermined for the study. This survey asked the

respondents to identify the percentage of that content they received in their

training and the percentage of that content they desired, total not to exceed 100%.

The Project Management Institute (PMI, 2000) conducted an international role delineation survey for the Project Management Professional (PMP) certification examination. Six major domains and sub-tasks were initially identified by technical experts, and then survey respondents were asked to rate these on the basis of importance, criticality, and frequency on a five-point Likert-type scale. Importance was defined as the degree to which it is essential for Project Management Professionals (PMPs) to be competent in the domain or task. Criticality was defined as the degree to which incompetence in the domain or task could bring about harm, while frequency was the percent of projects on which PMPs would perform duties associated with each domain. The sample size for this study was 826 professionals in the field of project management.

A similar role delineation study was also conducted by the Project Management Institute (PMI, 2002) for the Certified Associate in Project Management (CAPM) examination. The sample size for this study was 509 participants. A five-point Likert-type rating scale for criticality, importance, and frequency was used in the survey. The final phase of the role delineation study identified the proportion of questions from each domain and task that should appear on the certification exam. The overall evaluations of importance, criticality, and frequency were combined and converted into percentages for developing test specifications.

A job analysis study conducted by the Microsoft Company for its Microsoft Certified Systems Engineer (MCSE) certification (McKillip, 2001) had a sample size of 415. A five-point Likert scale was used to rate the importance of 91 job tasks. McKillip (2001) also described another job analysis study conducted for a Master's in Library Science (MLS) degree, the goal of which was to find out if further training in the form of a certification was needed to meet the challenge of keeping pace with library work. A 9-point Likert-type rating scale was used to measure the importance of the job tasks needed for their professional work. The scale was labeled (1) Not at all, (3) Minimally, (5) Somewhat, (7) Very, and (9) Extremely.

Patterson (1989) conducted a study to examine the validity of competencies defined by a role delineation study on the preparation and practice of health educators in Illinois. The subjects (health educators) were asked to rate the importance of each competency and also the use of the competency in their current position. The scale of importance was labeled very, neutral, and slight, whereas usage was a dichotomous scale: use, and do not use.

History of Role Delineation Studies at SME

The Society of Manufacturing Engineers (SME) conducted a series of studies over the last four decades to explore and update the body of knowledge that defines the discipline of manufacturing engineering. Tillman (1989) described these studies, which are summarized as follows:

1. 1968 - Arthur D. Little, Inc., conducted a study on groups such as SME members, readers of Manufacturing Engineering magazine, and attendees at

trade shows. The response rate for this study was 29.3% out of the 14,000 questionnaires sent.

2. 1978 – Battelle followed with a similar study and obtained a response rate of 28 percent from a sample of 6,558 member names.

3. 1982 – The Institute for Science and Technology at the University of Michigan conducted a Delphi study for SME on industrial robots. Three Delphi panels corresponding to three topics were surveyed, and the membership on each panel averaged 80 persons. The response rate for this study was 56%.

4. 1988 - The Industrial Development Division at the University of Michigan conducted another major Delphi study for SME, which was termed *Profile 21 – Countdown to the Future*. This study utilized two panels from the U.S. and Japan and had an average of 40 U.S. panel members in each of three rounds. While an average of 46 Japanese participated in each of two rounds, the study did not report the response rate.

5. 1989 – National Council of Examiners for Engineering and Surveying published an analysis of the professional activities and requirements of the manufacturing engineering profession based on their study on Professional Engineering (PE) registration for 14 engineering branches. A total of 7,666 surveys were mailed to registered and non-registered engineers, and an overall response rate of 57% was obtained (Buckly & Giffin, 1989).

6. 1989 – Tillman (1989) conducted a role delineation study for his dissertation research for the Certified Manufacturing Technologists and Certified Manufacturing Engineer certification exams. The research involved an initial pool

of 504 participants in the pre-Delphi round, out of which 51 Delphi panel experts were selected. Through three iterations of Delphi questionnaires, the study achieved an overall response rate of 95%.

7. 1999 – The Chauncey Group International conducted a job analysis study of manufacturing engineers for professional engineering licensure examination. The response rate of this study was 39.2%.

A job analysis of manufacturing engineering for use in professional engineering licensure and certification was conducted by SME in 1999 to identify knowledge and skills areas required for entry level performance as a licensed manufacturing engineer (Breyer & Bonell, 1999). In this study, respondents were asked to rate the seven major knowledge domains based on frequency of use and importance of the profession. The response rate for this survey was 39.2% out of the total 1398 surveys that were mailed out.

Tillman (1989) described the strategy that he and SME used for achieving a high response rate and a high quality study for his dissertation, by stating:

> The SME/MECI Rewrite Committee (1988) stated their preference for a Delphi study of experts' identification of competency areas over a sample survey. They felt that a traditional sample survey would pose problems of non-response, higher cost, and poorly qualified responses. Comparatively, they felt that a Delphi design would ensure a higher response rate and better qualified results – in an appropriate amount of time, and at a reasonable cost to MECI. (p. 72)

Based on these previous studies conducted for the field of manufacturing engineering, it can be concluded that for a primary major initial role delineation study for a certification examination, a Delphi study would produce richer and more valid results. However, for a check of currency and minor revisions to a body of knowledge for a certification exam, a one-time survey will suffice.

Hence, Tillman (2000) conducted a survey to update body of knowledge areas for certification testing of manufacturing technologists and manufacturing engineers (CMfgT and CMfgE), following a standard one-shot survey format used by National Council of Examiners for Engineering and Surveying (NCEES) for developing and updating Professional Engineering licensure exams. The participants were asked to rate the competency areas on a five-point Likert-type scale and also indicate the necessity of inclusion of a specific competency as a question on the certification exam. Necessity of inclusion of the competency area for certification exam was a dichotomous question that was answered by choosing either "yes" or "no." Out of the pool of 1400 sample subjects who were Certified Manufacturing Engineers, this study had a response rate of 32.4%.

Rating Scales

To adequately represent the major job characteristics, multiple Likert-type rating scales are commonly used to reflect separate aspects of the tasks, such as frequency of performance, criticality to public protection, and necessity (Wang, Wiser & Newman, 1999). Castle (2005) recommended that each task should be measured against a minimum of two attributes: importance of the task and how frequently the task is performed. Wang, Wiser, and Newman (1999) mentioned

that the effectiveness of different rating scales has been debated at length. Halo error occurs when raters attend to general, more salient attributes of the entity being rated by the rating scale, and it is a potential threat when two or more rating scales are used to rate tasks (Raymond, 2001). Moreover, it has been revealed through many instances that the scales measuring different attributes are highly correlated, which implies that the use of multiple scales is not very productive (Raymond, 2001). Wang, Wiser, and Newman (1999) conducted statistical analysis on job analysis studies conducted in two professions, and the results of these analysis confirmed that three rating scales are not necessary for a job analysis in that profession. These studies suggest that although high correlation among different rating scales can be considered as a positive outcome and can increase the precision, multiple rating scales are not necessary unless dealing with a highly critical profession such as medicine.

Delphi Technique

To obtain high validity, reliability, and quality of data, the research design used for this dissertation level research utilized a modified Delphi technique. The Delphi technique is a procedure to seek consensus from a panel of geographically dispersed experts and is considered to have a great potential for use in problem-solving, decision-making, strategic planning, and curriculum development. The Delphi technique is a procedure to obtain consensus on a particular topic through a set of carefully designed sequential survey questionnaires interspersed with feedback from the participants (Delbecq, Van

de Van, & Gustafson, 1975). It is structured to capitalize on the merits of group

problem-solving while minimizing its liabilities (Dunham, 1996). A Delphi study is

an attempt to bring the knowledge and intuition of a group of qualified individuals

to bear upon the future possibilities in a given field. A group or panel opinion is

sought concerning what likely will happen when all factors - social, technological,

economic, and political - are taken into account. The Delphi technique, therefore,

is an organized way of arriving at a qualitative forecast that may vary

considerably from past trends.

Delphi process

Ludwig (1997, cited in Leibowitz, 2002) explained how the development

and administration of questionnaires are interconnected. A multiple series of at

least three questionnaires are used. The first questionnaire would most likely

include open-ended questions related to broad problems or issues. The

researcher develops the second questionnaire based on information collected

during the first round. Participants are then asked to use a Likert-type rating

scale to establish preliminary priorities among the items identified in the first

round. During the third round, respondents prioritize items identified in Round

Two by ranking them in order of their importance (Ludwig, 1997). The Delphi

rounds of questionnaires should continue until a predetermined level of

consensus is reached or no new information is gained (Ludwig, 1997; Linstone &

Turoff, 1975; Delbec, Van de Ven and Gustafson, 1975). In most instances it is

found that three iterations are sufficient as not enough new information is gained

to warrant the cost of more iterations (Ludwig, 1997).

History of the Delphi Technique

The Delphi technique was developed by Dalkey and Helmer at the Rand Corporation to provide information for decision-making areas where exact data were required but unavailable (Tiedemann, 1986, cited in Jones, C., 1994). A series of experiments conducted by Dalkey in the 1950s discovered that when anonymous and controlled feedback was provided to members of a decision making group, more accurate decisions were produced than when such groups reached decisions by face-to-face discussions (Dalkey, 1969, as cited in Jones, 1994). These findings tended to support the use of the Delphi techniques a tool for the collection of information and expert opinion.

Sample Size

A literature review on Delphi studies indicates that there are varying views on determining a sample size. Adler and Ziglio (1996) suggested that good results can be obtained in a Delphi panel with small, homogeneous panels of 10 to 15 individuals. Ludwig (1997) suggested a sample size of 15 to 20. Delbecq, Van de Ven, & Gustafson (1975) suggested a sample size of 30 and view 10 to 20 as reasonable. Rowe (2001) involved approximately 14 panelists in a Delphi study to develop a test blueprint for a National Association of Industrial Technology (NAIT) certification examination. Tillman (1989) utilized approximately 50 experts for a Delphi study to identify competency areas for the Certified Manufacturing Technologist (CMfgT) examination. Parker and Taylor (1980) involved more than one hundred participants in their Delphi study to identify competency-based adult education. Shah (2004) conducted a study

using about 200 panel members to gather data using the Delphi technique to discover and describe what experts in the field consider important to know in the discipline of engineering management.

Response Rates

Response rate is a major concern while conducting any kind of survey research. Asher (1976) suggested picking small samples so that each sampling unit in the sample can be vigorously pursued in order to avoid a lack of response. Tillman's (1989) dissertation Delphi study yielded an average response rate of 95 percent over three rounds, using 51 Delphi panel members. Williams, Boone, and Kingsley (2004) utilized 69 participants for a study on teacher beliefs about educational software and obtained a return rate of 69 percent for their surveys. Fleming and Monda-Amaya (2001) conducted a Delphi study of wraparound team members to find out process variables critical for team effectiveness. Twenty panel members were surveyed, and a 90 percent response rate was achieved at the end of Round Two. Shah (2004) conducted a Delphi study on engineering management curriculum using about 200 participants and obtained an overall response rate of about 73 percent. Use of follow-up reminders sent to the panelists, either through a phone call, email, or post card, was one of the reasons for a high response rate in these Delphi studies.

Henderson (1990, as cited in Baruch, 1999) mentioned that a response rate of 20-30% is typical for a mail-out survey to a large sample of subjects (p. 423). Paxson, Dillman, and Tarnai (1995, as cited in Dennis, 2003) reviewed 180 studies from academic and trade literature related to business respondents

in the early 1990s and reported that an average response rate of 21 percent was achieved across these studies. Although the response rate varies from type of industry, target population, and so on, studies on survey research have found a decline in mail survey response rates over the last two decades. Baruch (1999, as stated in Dennis, 2003) reported that average response rates declined about 16 percentage points over 20 years between 1975 and 1995 in mail surveys focused on larger firms. An experimental study conducted by Larson and Chow (2003) on 1800 purchasing professionals received a response rate of only 13% for the group with no personalized letter and no follow-up. Cycyota and Harrison (2006) analyzed response rate data from 231 studies that surveyed executives and from top management journals from 1992-2003 using a meta-analysis procedure. Their study concluded that mean response rates have been declining over the period, and "typical" response rate among executives was at a median of 32% with an interquartile range from 20% to 46%. It should be noted that the studies considered for this study included some type of follow-up, personalization, advance notification, consent screen, or social network.

Asher (1976) recommended that, "An 80 to 90 percent response rate is needed from the identified sample for reasonable assurance that the samples' estimates of the populations' values and incidences will be reasonably accurate" (p. 170). Babbie (1990, as cited in Hager et al., 2003) stated that a return of 50% is adequate. Schutt (1999, as cited in Hager et al., 2003) mentioned, "A response rate below 60 percent is a disaster. It is hard to justify the representativeness of the sample if more than a third failed to respond" (p. 254).

Based on the review of literature conducted, it can be concluded that a use of Delphi methodology is relevant to this research to obtain a high response rate.

Strengths of the Delphi Method

Delbecq, Van de Ven, and Gustafson (1975, as cited in Jones, 1994) identified five areas of research that have effectively utilized Delphi methodology: (a) to determine or develop a range of possible program alternatives; (b) to explore or expose underlying assumptions or information leading to different judgments; (c) to seek out information that may generate a consensus on the part of the respondent group; (d) to correlate informed judgments on a topic spanning a wide range of disciplines; and (e) to educate the respondent group as to the diverse interrelated aspects of the topic (pp. 10-11).

The Delphi methodology allows a collection of opinions from geographically dispersed experts (Delbecq & Van de Ven, 1975). This methodology also produces more accurate group estimates than do face-to-face discussions (Riggs, 1983). Moreover, the benefits of obtaining accurate and thoughtful consensus from a group of geographically dispersed experts outweighs the time required to perform a Delphi study relative to a one-shot survey.

Limitations of the Delphi Method

Since there are at least three rounds of questions, a person must have some interest in the topic to participate. A lack of interest can lead to a low participation rate. The best way to increase this rate is through an effective cover

letter and at least one follow-up reminder. Another limitation is that some questions posed to the Delphi panel may remain unanswered. When this occurs, it must be determined whether the answers may be worth another round of questions for all groups (Blair & Uhl, 1993).

Statistical Methods to Obtain Reliability in Delphi Technique

Yang (2003) conducted a study to test the stability of opinions of the experts between successive rounds of Delphi study by using nonparametric statistical methods: (a) the McNemar change test and (b) the Binomial test. This study analyzed the data with a sample size of 24 in a Delphi study conducted over three rounds. The results of this study indicated that the McNemar change test could be robust even if the correction for continuity was not made, and that the McNemar test was not as conservative as the Binomial test.

Parametric statistical methods such as coefficient of variation (CV) and F-test have also been used in Delphi studies with a sample size below 50. Coefficient of variation is a statistical measure of the deviation of a variable from its mean. F-test is performed to determine the ratio of squares of two variances, or, in other words, to test if the standard deviations of two populations are equal.

English and Kernan (1976, cited in Yang 2003) used the coefficient of variation to determine the stopping rule, i.e. a deciding point after which no further rounds are necessary. If the magnitude of CV for an item was found to be too large (e.g. > 0.8), the corresponding statement was needed to be modified and required an additional round(s) of questionnaire.

Yang (2003) also mentioned using the F-test to compare two variances.

The F-value is determined by the ratio of the variances of item scores among panelists between the two successive rounds. If there is no significant difference in the F-test, the questionnaire item will be dropped from further rounds. Questionnaire items where significant between-round difference in variances is found are retained in a subsequent round. Yang (2003) described this method as being suggested by Jolson and Rossow (1971) with the problem being that assumptions made for the F-test may be seriously violated when using data that is collected from different Delphi rounds.

Statistical analysis for obtaining reliability was conducted by Shah and Kalaian (2005) on a sample of more than 50 participants. This study compared the three parametric statistical techniques used to obtain reliability in a Delphi study, namely F-test, coefficient of variation (CV), and Pearson's Product-Moment Correlation (r). The results of this study indicated that CV was the best procedure to measure the internal reliability in a Delphi study. Moreover, the study also confirmed that three rounds of Delphi study are enough to warrant stability of responses in such a study.

Mail and Internet Surveys

Role delineation studies have been carried out in the past using both mail and Web-based surveys. However, it is becoming increasingly common to use the Internet for survey delivery since the Internet provides an effective method of collecting data (Dillman, 2000). Raymond (2005) suggested that it still may be necessary to use conventional mail to establish contact with study participants. He also recommended that it is equally important to evaluate the survey tool for

compatibility with Internet delivery. The advantages of Internet surveys are as follows (Raymond, 2005; Archer, 2005):

1. Complete elimination of paper, postage, mail out, and data entry costs.

2. Reduced time required for implementation.

3. International population can be accommodated in the study with no extra cost.

4. Reminders and follow-up on non-respondents are relatively easy.

5. More dynamic interaction with respondents can be obtained.

The limitations of Internet surveys are (Archer, 2005; Dillman, 2000):

1. This method will not work for all populations, since everyone does not have access to the Internet.

2. Computer literacy of respondents is necessary.

3. Screen configurations may appear significantly different from one respondent to another based on individual settings of the computer, such as Mac vs. PC.

4. Internet-based surveys may be detected as "junk" mail due to the sophistication of modern email programs.

Since role delineation studies typically consist of 75-200 job related phrases, the questionnaire becomes lengthy and poses a challenge to Internet delivery. "A general rule of thumb for Internet questionnaires is that they be no less convenient to complete than those printed on paper" (Raymond, 2005, p. 35). Dillman (2000) outlined the following design principles for Web-based questionnaires:

1. Introduce the Web questionnaire with a welcome screen that is motivational, emphasizes the ease of responding, and instructs respondents about how to proceed to the next page.

2. Provide a PIN for limiting access to only those people in the sample.

3. Present each question in a conventional format similar to that normally used on paper self-administered questionnaires.

4. Restrain the use of color so that figure/ground consistency and readability are maintained, navigational flow is unimpeded, and measurement properties of questions are maintained.

5. Provide specific instructions on how to take each necessary computer action for responding to the questionnaire, and give other necessary instructions at the point where they are needed.

6. Use drop-down boxes sparingly, consider the mode implications, and identify each with a "click-here" instruction.

7. Do not require respondents to provide an answer to each question before being allowed to answer any subsequent ones; Use "skip logic" if possible.

8. Provide skip directions in a way that encourages marking of answers and being able to click to the next applicable question.

9. Use graphical symbols or words that convey a sense of where the respondent is in the completion process, but avoid those that require significant increases in computer resources.

10. Exercise restraint in the use of question structures that have known

measurement problems on paper questionnaires, such as check-all-that-apply

and open-ended questions. (pp. 377-398)

In addition to these recommendations, Raymond (2005) has suggested

the following regarding questionnaire format and administration:

1. Use a cover letter that describes the purpose of the study, how

respondents were selected, and how confidentiality will be maintained. Indicate

the time required to complete the questionnaire, the date to respond by, and how

to return it (when using a mailed questionnaire). When feasible, use official

letterhead and a personally signed letter from a trusted authority.

2. Plan on at least two and up to four mailings that include a thank

you/reminder postcard, followed two to three weeks later by a second

questionnaire mailing to nonrespondents.

3. The font should be large enough to read easily. Minimize uppercase-

only text. Use features such as bold, italics, and underlining consistently.

4. Give the survey a tidy and navigable appearance. Avoid squeezing too

much text onto a page to make the questionnaire appear shorter

5. For stand-alone questions (e.g. demographics) with ordinal scales, use

a vertical arrangement of response options. A two-column page layout is easier

to read and uses space in a better way.

Rate of response is a major concern while conducting a survey. Archer

(2005) conducted a study to determine the effect of the number of reminders on

response rate of Web-based surveys. The study concluded that reminders sent

on day seven of the eleven-day survey produced the largest increase in

responses. The study also recommended using three total contacts with the respondents which includes initial invitation, first reminder, and final reminder.

Dillman (2000) suggested the proven use of five elements to significantly improve response to mail surveys, which are

    1. A respondent-friendly questionnaire.

    2. Up to five contacts with the questionnaire recipient.

    3. Inclusion of stamped return envelopes.

    4. Personalized correspondence.

    5. A token financial incentive that is sent with the survey request. (p. 150)

A study conducted by Shah (2004) indicated that an original signature on the cover letter adds value to the survey and shows personal interest of the researcher in the study. It can also be a factor in improving response rate. Shah also sent reminder postcards to complete the survey, and that led to an improved response rate of approximately 70%.

Summary

This chapter presented a review of literature that provides a framework and background for this research. Various standards and guidelines related to certification examination development and maintenance were presented. The literature review also presented examples and steps procedural for role delineation studies conducted by various certification agencies. The nature and use of a modified Delphi technique was also reviewed along with an explanation of its suitability for this research. The specific application of this methodology will be described in the next chapter.

CHAPTER III. METHODOLOGY

Introduction

The focus of this study was to conduct a role delineation study and obtain information from experts in the field of lean manufacturing in order to validate the lean manufacturing prototype body of knowledge (BOK) developed by SME/AME/ Shingo. This chapter will describe the modified Delphi technique that was used for this study.

Research Design

A modified Delphi technique with qualitative and quantitative components was used to survey the participants and achieve the objective of this study. The Delphi technique utilizes a panel of experts to achieve group consensus on a particular topic through a series of carefully designed sequential questionnaires interspersed with feedback from the participants. The use of the Delphi technique permits the avoidance of face-to-face discussions, which are expensive and may lead to inaccurate results due to the dominance of an opinion leader (Keech, 1998). Moreover, the decisions are more valid when experts in the field are involved in the study. Hence, use of the Delphi technique was appropriate for this research.

General Methodology

Consistent with the methodology used in a general Delphi study, a pre-Delphi study was conducted to obtain a sample of experts for further rounds of the study. Three rounds of Delphi questionnaires were conducted, and the Delphi

panel experts responded to the qualitative and quantitative components of the questionnaire. The Delphi rounds of questionnaires should continue until a predetermined level of consensus is reached or no new information is gained (Ludwig, 1997; Linstone & Turoff, 1975; Delbec, Van de Ven, & Gustafson, 1975). In most instances it is found that three iterations are enough, as not enough new information is gained to warrant the cost of more iterations (Ludwig, 1997). Hence, the Delphi methodology used for this study consisted of a Web-based pre-Delphi study and three rounds of email-based and paper-based questionnaires.

Using the results of a review of literature and competency areas tested by the current lean manufacturing certification examination, an initial list of competency areas was presented to a sample of participants via a Web-based survey during the pre-Delphi round. The questionnaire in the pre-Delphi round was quantitative in nature, with additional spaces provided to the participants to include any additional competency areas that they believed to be important to include in the lean body of knowledge.

Responses to a set of demographic questions in the pre-Delphi survey were used to select Delphi panel experts for subsequent Delphi rounds. In Round One, the panel members were asked to provide both quantitative and qualitative feedback on the competency areas. During the second questionnaire round, an analysis made of the first round's results was provided for reference. Qualitative feedback obtained from the open-ended questions for each response was provided verbatim along with possible additions or modifications recommended

from Round One. Similarly, in Round Three, an analysis made from Round Two was provided to the panel of members, and final modifications recommended by them were incorporated.

Validity and Reliability of the Technique

The Delphi technique is considered to have a great potential for use in problem-solving, decision-making, strategic planning, and curriculum development. It has also been used in identifying competencies and personal characteristics needed by future community college chief executive officers (Hammons & Keller, 1990; as cited in Murray & Hammons, 1995). The Delphi method is more effective than a conference because participants do not have to arrange and attend a meeting, respondents may remain anonymous to each other, domination by individuals is prevented, adequate time is provided for thinking and reflection, participants are granted flexibility in responding, and conformity issues are avoided (Price, 1998).

The validity and reliability of the Delphi technique has been addressed in numerous studies (Dalkey, Rourke, Lewis, & Synder, 1972; Delbecq, Van de Ven, & Gustafson, 1975; and O'Connell, 1974; as cited in Price, 1998, p.8). Internal validity is high because the initial round produces responses that are affirmed through quantitative means in subsequent rounds. Since the Delphi technique involves statistics to quantify group response, it ensures that all respondents' opinions are represented in the final response (Dalkey, Rourke, Lewis, & Synder, 1972; as cited in Price, 1998). O' Connell (1974, as cited in

Price, 1998) claims the reliability of Delphi has shown to be high because group consensus is more dependable than an individual's opinion.

<div align="center">Research Setting</div>

The panel members participating in this study were from within and outside the United States. Both Web-based and mail surveys were used to overcome the limitations of either survey procedure.

<div align="center">Population and Sample</div>

Since the Delphi method requires that questionnaire respondents be experts, criteria are established to define who will participate as expert panel members in the study. Linstone and Turoff (1975) stated that the researcher can determine which experts may participate in the Delphi process, as long as expertise is considered "expert knowledge upon which professional authority can be founded" (p. 295). The following characteristics were used as pre-qualifiers for individuals to be considered "experts in the field of lean manufacturing": experts and practitioners in lean manufacturing from industry and academia. Hence, a purposeful sampling method was employed to select the experts based on: (a) the level of expertise in lean manufacturing, (b) commitment to serve on the Delphi panel, and (c) years of experience in lean. Judgment regarding the level of expertise was based on self-rating of the respondents during the pre-Delphi study.

Raymond (2005) recommended that for role delineation studies, the samples should be large enough to support the types of analyses and statistical inferences required for a project. Although many role delineation studies have

been conducted with sample sizes exceeding 1000 individuals, some studies have demonstrated that for uncomplicated descriptive studies, adequate generalizability can be obtained from 200 to 400 respondents (Kane et al., 1995; as cited in Raymond, 2005). Adler and Ziglio (1996) suggested that good results can be obtained in a Delphi panel with small, homogeneous panels of 10 to 15 individuals. Ludwig (1997) suggested a sample size of 15 to 20. Delbecq, Van de Ven, & Gustafson (1975) suggested a sample size of 30, and view 10 to 20 as reasonable. Parker and Taylor (1980) involved more than 100 participants in their Delphi study, and Shah (2004) conducted a Delphi study with approximately 200 experts. Tillman's (1989) dissertation Delphi study utilized 51 panel experts, while this Delphi study used 76 panel experts. Based on the literature, 76 panelists is a representative sample of experts and provides good statistical power for analysis.

The sample group used for this study was obtained by contacting the members of the Society of Manufacturing Engineering (SME) and the Institute of Industrial Engineers (IIE). Approximately 6000 subjects with email addresses were randomly selected based on their interest in lean from the SME database and IIE directory of members. Flyers were posted at the Association for Manufacturing Excellence (AME) conference held during October 18-21, 2006, to advertise the study and to obtain lean experts to participate in the study. A copy of the flyer is provided in Appendix D. SME took an initiative to send the pre-Delphi survey to these subjects via email. The email had a SME logo followed by a message signed by the researcher and the manager of certification from SME

that provided information on the Web link to access the survey website.

Response from 138 subjects was obtained from the pre-Delphi survey, out of

which 102 Delphi panel members were selected for the first Delphi round based

upon the following reported information, which is listed in order of importance: (a)

commitment to serve on the Delphi panel, (b) self-rating of their expertise in lean

(greater than or equal to 3 on the Likert scale), and (c) years of experience in

lean. During Round One, the Delphi panel members who were selected to

participate in the study but did not respond to Round One questionnaire were

contacted to verify if they were interested in being a part of the study. Based on

their responses the Delphi panel was reduced from 102 preliminary members to

76 final members.

<div align="center">Overview of Data Collection Procedure</div>

The Delphi method consists of a series of rounds of questionnaires. The

first round is characterized by exploration of the subject under discussion,

wherein each individual contributes information he or she believes pertinent. The

second round involves the process of reaching an understanding of how the

group views the issue (i.e., what group members mean by relative terms such as

importance, desirability, or *feasibility*). The final evaluation occurs after Round

Three, once all previously gathered information has been analyzed and the

evaluations have been fed back for consideration (Linstone and Turoff, 1975).

A Delphi procedure consisting of three rounds of questionnaires and a

pre-qualifying round was used for conducting this study. The pre-Delphi

questionnaires were distributed to the participants via an Internet-based survey. Based on the degree of expertise and commitment to participation indicated by participants, a purposeful sample of experts was selected to create the panel to be used for the three Delphi rounds. Three rounds of Delphi questionnaires were sent to the Delphi panel experts: those located within the United States received them via postal mail and those located internationally received them as electronic questionnaire.

This research plan received approval from the Human Subjects Review Committee at Eastern Michigan University in July 2006. Related documentation and the approval letter are provided for reference in Appendix C. The detailed research proposal was formally approved by the dissertation committee members in October 2006, after which the data collection process was initiated.

Instrumentation

The Delphi technique was used to obtain the experts' opinions through mailed and electronic questionnaire iterations. A preliminary list of potentially important competency areas was extracted from the most recent version of the lean manufacturing certification BOK for the Web-based pre-Delphi survey. Participants were asked for demographic information and were also asked to rate the competency areas currently included in the BOK for lean certification. A copy of the pre-Delphi questionnaire is included in Appendix E. The pre-Delphi questionnaire consisted of (a) an email message that was sent to the participants signed by the researcher and manager of certification from SME, (b) an informed consent form, (c) demographic questions, and (d) competency areas for rating.

The pre-Delphi questionnaire also contained an open-ended item that allowed the respondents to suggest additional competency areas other than those already mentioned in the questionnaire. These additional areas were included in the Round One, Two, and Three Delphi questionnaires, with comments and ratings by the panel experts.

The participants were asked to judge the importance of a particular competency area for the lean manufacturing exam using a 5-point Likert-type Scale. The following criterion of importance was assigned to the responses provided on the questionnaire given to them, along with an example of how to respond: 4= Extremely important, 3 = Very Important, 2 = Important, 1 = Of little importance, 0 = Not important. A dichotomous type question of "yes" or "no" was asked to identify the necessity for each specific competency area to be included at each lean certification exam level.

The pre-Delphi study was conducted on a stratified sample of individual SME members from a list provided by SME and IIE member directories. The primary purpose of the pre-Delphi study was to identify a group of experts to participate in the study based on demographic information: (a) education level completed, (b) place of residence, (c) years of experience in lean manufacturing, (d) current position within the company, and (e) commitment to serve on the Delphi panel. The pre-Delphi questionnaire was pre-tested for comprehension of the instructions, length of time for completion, appropriate use of terminology, and clarity of the competencies by members of my dissertation committee. The pre-test helped to assure content validity of the instrument. The pre-Delphi study

was then sent to the target population under study as a Web-based survey. To overcome the limitations of a Web survey, Rounds One, Two, and Three of the Delphi study used mailed questionnaires with an option of using an emailed questionnaire for the panel members who were overseas and other members who preferred filling it electronically.

Round One of the Delphi study (see Appendix F) consisted of (a) a cover letter with instructions to Delphi panelists to complete the Questionnaire, (b) Round One Questionnaire with additional areas suggested by the pre-Delphi respondents, and (c) pre-Delphi group's modal response and percents of concurrence for each degree of importance. Space was provided below each competency area to provide an explanation if their choice was two or more categories away from the group's modal rating. Moreover, additional space was also provided at the end of the questionnaire for the panel members to write in any additional comments.

A self-adhering label was attached on the front page of each mailed questionnaire, which listed the panel member's name and a five-category numerical code with each number followed by a punctuation mark, i.e., a.b.c.d.e. The first digit (a.) represented the rating of the commitment of the panel member; the second digit (b.) represented level of expertise; third (c.), residence; fourth (d.), position; and fifth (e.), panel member's assigned number based on demographic information. A pre-paid business reply envelope was sent with each mailed questionnaire.

During Round Two, an analysis of the first round's results was provided as a separate document for reference. Round Two (see Appendix G) used the same basic instrument as Round One and presented modal and percents of concurrence scores for each competency area from Round One results. Round Two was administered in the same manner as Round One. The Round Three Delphi questionnaire (Appendix H) was developed based on the Round Two results. Additional questions were asked in the beginning of Round Three questionnaire to (a) rate the importance of the results of the study to the field of Lean manufacturing, (b) rate the overall quality of the study, and (c) provide any additional comments regarding the importance and/or quality of the study along with any suggestions for possible improvement. Round Three was administered in a manner similar to that of Round Two.

To enhance the visual appearance and to help identify each Delphi round questionnaire, Round One was printed on gray paper, Round Two on blue, and Round Three on yellow. Results of the previous rounds that were provided to the panel members were printed on same colored paper to maintain consistency across every round of questionnaire and to communicate final results.

<center>Data Collection</center>

The pre-Delphi questionnaire was sent to approximately 6000 subjects via email by SME. An email message that described the research, procedure, and participation of the members included a Web-link to the pre-Delphi survey. After ten days a reminder email was sent by SME on behalf of the researcher, requesting the subjects to participate in the study. One hundred and thirty-eight

responses were received at the end of the pre-Delphi study.

Based on the responses received from the demographic questions of the pre-Delphi survey, 102 panel members were selected to participate in Round One of the Delphi study. The Round One questionnaire (see Appendix F) consisted of a cover letter on Eastern Michigan University's letterhead, a letter of support from SME, and a postage-paid business reply envelope addressed to the School of Engineering Technology, Eastern Michigan University, and was sent by first-class mail to domestic participants. An electronic version of the same was sent to the participants who were located overseas. After about 10 days, a reminder email was sent to all the participants. A second reminder was sent as a postcard to the domestic participants and via email to international participants 10 days after the first reminder. A Delphi panel membership email was sent to those who did not respond to the Round One questionnaire even after two reminders. The purpose of this email was to verify whether the participants were interested in serving as Delphi panel experts on the study. An email was sent to the participants who did not respond regarding their interest in serving as panel members, stating that they had been dropped out from the study. At the end of Round One, 74 panel members responded to the study and two others expressed interest in pursuing the study in the subsequent Delphi rounds. Thus, the Delphi panel was narrowed down to 76 experts in the field of lean manufacturing.

The Round Two questionnaire (Appendix G) was sent to these 76 Delphi panel experts. A reminder email was sent after 10 days to both domestic and

international participants. The Delphi panel members were told that if they preferred filling in an electronic version over to paper copy of the questionnaire, then they should contact the researcher. Ten days after sending the first reminder email, a second reminder was sent as a postcard to domestic members via United State Postal Service's (USPS) NetPost Services online and as an email to the participants located overseas. To increase the response rate, a third reminder email was sent to all panel members about 15 days after the second reminder.

Round Three data were collected in a similar manner, including three reminders with the second reminder sent as a postcard via USPS to the domestic panel members. The reminder email messages for Round Three are shown in Appendix H.

<div align="center">Data Analysis</div>

A search of the literature and examination of the data analysis methods used in different fields of study indicated that the methodology utilized by Tillman (1989) and Shah (2004) was most applicable to this study. The additional competency areas suggested by participants in the Pre-Delphi survey were analyzed and added to the Round One questionnaire under each domain based on the researcher's judgment and analysis. In Round One, each of the competency areas was given modal and percent of concurrence scores from the pre-Delphi survey results. Data analysis during the first round of the process was conducted once all Round One feedback was returned. Each of the competency areas rated in Round One of Delphi study were given modal and percent of

concurrence scores, which were then reflected in the Round two Delphi questionnaire. Additional comments from Round One that addressed more general concerns about the study were provided in the "Round One Results" document. Data analysis of Round Two was conducted in the same manner as in Round One. Similarly, Round Two results were reported in the Round Three questionnaire. Data analysis of Round Three was performed in the same manner as for Rounds One and Two.

Based on a study of Delphi data analysis by Shah and Kalaian (2005), the Coefficient of Variation (CV) value was analyzed to measure reliability of each round of the Delphi study. The literature indicated that a Coefficient of Variation lower than 0.8 demonstrates a convergence of responses, indicating a trend toward general agreement on the issue, proving that reliability is obtained in the responses.

To obtain convergence of opinion, the mean of the standard deviation for each round was calculated. A decrease in the mean standard deviation value indicated a greater convergence of opinion among the panelists. On the basis of the standard deviation scores, the following four categories (as shown in Table 5, p. 66) of the prioritized list were formed: (a) higher mean score, lower standard deviation; (b) higher mean score, higher standard deviation; (c) lower mean score, higher standard deviation; (d) lower mean score, lower standard deviation. A decision of high and low mean and standard deviation were based on the range of results obtained in each category of analysis. An approach taken by Shah (2004) and Tillman (1989) was followed to determine a cut-off point for

defining high and low mean and high and low standard deviation. Higher and

lower values of standard deviations were determined based on the median value

of standard deviation under each domain.

Category I indicated that its competency areas are considered to be

important for candidates to know for the lean certification exam, and there was

relative agreement among panel members on their importance. Category II

indicated that its competency areas are also considered to be important for the

certification, but there was less relative agreement among panel members on

their importance.

Table 5.

Matrix to Portray Categories for Prioritization

	Standard Deviation in Scoring	
	Low	High
High ↑ Mean Score ↓ Low	I Higher Agreement of Greater Importance	II Lesser Agreement of Higher Importance
	IV Higher Agreement of Lower Importance	III Lesser Agreement of Lower Importance

Category III indicated that its competency areas were less important for a

lean certification exam than competency areas in Categories I and II, but that

there was less relative agreement among panel members concerning the

competency areas' levels of importance. Category IV indicated that those

competency areas are also considered less important for lean certification than competency areas in Categories I and II, and that there was relative agreement among panel members on their lower levels of importance.

To determine the percentage of items to be included under each domain area, the procedure used by Tillman (2000) was followed. The percentage of items to be included was calculated by determining a combined grand average of importance and "Yes" percent ratings for each competency area within each domain. The difference between the body of knowledge (BOK) delineated in SME's prototype BOK and that found in the study was depicted using a tabular format. This table (Table 24, p.109) highlights the differences between the existing BOK and that obtained through the results of this study.

Final results of the study along with the results obtained from Round Three were mailed to the Delphi panel members and to the manager of certification at SME. The final results were sent in a report format (Appendix I), and a recommended body of knowledge with additional suggestions was included in that report.

Personnel

Support Personnel

Continuing Education (CE) personnel at Eastern Michigan University assisted the researcher in uploading the pre-Delphi Web survey on the CE website. No additional support personnel were needed for this research.

Timeline

The Gantt chart on the next page shows the tasks involved in this project along with the durations, start dates and finish dates. The major milestones of this study were:

1. Proposal acceptance by Ph.D. Candidacy Committee – October 2006

2. Data Analysis from Pre-Delphi study – January 2007

3. Data Analysis from Round One Delphi study – February 2007

4. Data Analysis from Round Two Delphi study – April 2007

5. Data Analysis from Round Three Delphi study – July 2007

6. Dissemination of final results to the Delphi panel and SME – August 2007

Figure 1 (p. 70) is a detailed outline of the schedule in the form of a Gantt chart. After the acceptance of the proposal by the Ph.D. Candidacy committee on October 11, 2006, the Pre-Delphi survey was sent out on October 26, 2007. A follow-up email was sent on November 7, 2006.

Round One of the Delphi study was mailed to the panel members on January 22, 2007 and the three reminders were sent on February 2, 13, and March 2, 2007 respectively. The Delphi panel members who did not respond with their interest to pursue with the study after the three reminders were sent an email on March 19, 2007 stating that they have been dropped out of the panel. Round Two was developed and mailed out in both paper and electronic versions on March 19. Three follow-ups to respond to the Round Two questionnaire were done on April 2, 12, and 27. Round Three was constructed and sent on May 10,

2007. Reminders to participate in the final round were sent on May 21, June 11, and June 26.

Final results of the study were analyzed using SPSS and Microsoft Excel software. The final report was mailed out to all the 76 Delphi panel members on August 15, 2007. It took about one and half years to complete the study, starting from the conceptualization phase to its closure.

Task Name	Duration	Start	Finish
− Dissertation Research	434 days	Mon 5/8/06	Wed 12/19/07
− Develop Proposal	118 days	Mon 5/8/06	Wed 10/11/06
Obtain HSRC Approval	47 days	Mon 5/8/06	Tue 7/11/06
Proposal for Review	53 days	Wed 5/31/06	Thu 8/10/06
Finalize Proposal	20 days	Fri 8/11/06	Mon 9/4/06
Proposal Presentation to Committee	1 day	Wed 10/11/06	Wed 10/11/06
− Pilot Survey	113 days	Fri 8/11/06	Fri 1/5/07
Develop Pilot Survey	41 days	Fri 8/11/06	Mon 10/2/06
Survey Review by Committee	6 days	Fri 9/29/06	Fri 10/6/06
Finalize Pilot Survey	4 days	Mon 10/9/06	Thu 10/12/06
Pilot Survey to Population	30 days	Thu 10/26/06	Fri 12/1/06
Data obtained from Pilot	10 days	Mon 12/4/06	Fri 12/15/06
Data Analysis from Pilot	15 days	Mon 12/18/06	Fri 1/5/07
− Delphi Round I	48 days	Mon 1/8/07	Mon 3/12/07
Develop Delphi Round I	8 days	Mon 1/8/07	Wed 1/17/07
Round I finalized	2 days	Thu 1/18/07	Fri 1/19/07
Round I sent to Delphi panel	1 day	Mon 1/22/07	Mon 1/22/07
Round I data obtained	30 days	Tue 1/23/07	Thu 3/1/07
Round I data analyzed	7 days	Fri 3/2/07	Mon 3/12/07
− Delphi Round II	57 days	Tue 2/20/07	Tue 5/8/07
Develop Delphi Round II	10 days	Tue 2/20/07	Mon 3/5/07
Round II approval	5 days	Tue 3/6/07	Mon 3/12/07
Round II finalized	5 days	Tue 3/13/07	Sun 3/18/07
Round II sent to Delphi Panel	1 day	Mon 3/19/07	Mon 3/19/07
Round II data obtained	35 days	Tue 3/13/07	Fri 4/27/07
Round II data analyzed	7 days	Mon 4/30/07	Tue 5/8/07
− Delphi Round III	67 days	Tue 4/10/07	Wed 7/11/07
Develop Round III	10 days	Tue 4/10/07	Mon 4/23/07
Round III approval	5 days	Tue 4/24/07	Mon 4/30/07
Round III finalized	7 days	Tue 5/1/07	Wed 5/9/07
Round III sent to Delphi Panel	1 day	Thu 5/10/07	Thu 5/10/07
Round III data obtained	30 days	Fri 5/11/07	Thu 6/21/07
Round III data analyzed	14 days	Fri 6/22/07	Wed 7/11/07
− Final Results	115 days	Thu 7/12/07	Wed 12/19/07
Analysis of qual & quant data	20 days	Thu 7/12/07	Wed 8/8/07
Final Results sent to Panel & SME	1 day	Thu 8/23/07	Thu 8/23/07
Dissertation Write up	30 days	Thu 7/12/07	Wed 8/22/07
Dissertation Review by Committee	60 days	Thu 8/23/07	Wed 11/14/07
Dissertation Finalization	10 days	Thu 11/15/07	Wed 11/28/07
Oral Defense	1 day	Wed 12/19/07	Wed 12/19/07

Figure 1. Gantt chart for the research project.

Summary

This study used a combination of qualitative and quantitative research designs to analyze which competency areas in the field of lean manufacturing the experts suggest are important to be included on the lean manufacturing certification examination. The individuals selected to serve on the Delphi panel were chosen based on their commitment, level of expertise, and experience in lean manufacturing. A five-point Likert Scale was used to record the data obtained from the study. Data collection and analysis for the study was completed by August 2007.

CHAPTER IV. DATA PRESENTATION AND ANALYSIS

Introduction

This chapter will provide a presentation and analysis of data collected from the pre-Delphi survey and all three rounds of the Delphi study based on the methodology described in Chapter III.

Data Presentation and Analysis Overview

In the pre-Delphi round of the study, the data collected and analyzed consisted of (a) background information of the panel members in terms of frequency and percentage, (b) means and standard deviations of responses to the competency areas, and (c) modal and percentage concurrence scores.

The data presented and analyzed from the three Delphi rounds consisted of (a) response rates from the questionnaire rounds, (b) modal and percentage concurrence of scores, (c) means and standard deviations of responses to competency areas in Round Three, (d) coefficient of variation (CV) values for Round Three, (e) general comments on the study, (f) specific comments regarding competency areas, and (g) percentage and number of items to be included under each domain for each certification level.

A prioritized list of competency areas within each domain for each level of examination was generated from the analysis of the data. The specific comments provided by the Delphi panelists were useful in determining if a particular competency area were necessary to be included on the examination and how modifications could be made on the body of knowledge to

group/ungroup different areas. Thus, the recommended body of knowledge is based on both quantitative and qualitative data.

Response from the Pre-Delphi Study

Table 6 contains the background information provided by the Delphi panel experts who were selected to serve on this study. Based on the responses obtained from the pre-Delphi round, 102 participants were selected to participate in the first round of the study based on their expertise, commitment, and experience. During the first Delphi round, 76 panel members participated in the study and expressed interest in continued participation in subsequent Delphi rounds. Thus, this Delphi study included 76 panel members. The demographic information of the panel is given in Table 6. The frequency of responses, mean, and standard deviation for each competency area in the pre-Delphi study are provided in Appendix J.

Table 6

Demographic Information of the Delphi Panel Experts

Demographic Questions	N	Percent
1. What is your age group?		
Under 25	--	
25-34	10	13
35-44	22	29
45-54	22	29
55-64	17	22
65 or over	5	7
2. What is the highest level of education that you have completed?		
High School	4	5
Associate Degree	4	5
Bachelor's Degree	24	32
Master's Degree	35	46
Doctorate	7	9
Other – DD, Several college years	2	3

Table 6 (continued)

Demographic Information of the Delphi Panel Experts

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3. Which of the following professional designations do you hold?

	N	Percent
CEI	1	1
CEM	1	1
PE	8	10
CMfgE	3	4
CMfgT	3	4
None	44	56
Other (please specify) – *ASQ_CSSBB; Bachelor in Engineering & Fulbright Fellow from Carnegie; CDP, CSP, CFPIM, CIRM; CQM, CQEgr; Chartered Engineer (similar to PE); Chemical Engineer; CQE, CQA, CMGR; CSSMBB, CLS, CMC; Diploma-Ing; EIT, Electrical Engineer; EMCP; GE Black Belt; Industrial Engineering; Journeyman tool and die maker; Lean Certification Bronze Level; Lean Six Sigma Champion, ASQ CQE;* PMP; SME Bronze Lean	18	24

4. Which of the following most closely describes your current position within your organization?

	N	Percent
Senior Management	22	29
Mid-level Management	18	24
Consulting/Private Practice	10	13
College/University Faculty	4	5
Design/Engineering	2	3
Manufacturing/Operations/Quality/Support	12	16
Other (please specify) – *Consultant; Internal consultant; Lean Champion; Lean Coordinator; Owner; Retired; Six Sigma Black Belt; Sr. Management of Company*	8	10

5. Which of the following best describes the place of your residence?

	N	Percent
Northcentral United States (IL,IA,KS,MI,MN,MO,NE,SD, WI)	19	25
Northwest United States (ID, MT, OR, WA, WY)	1	1
Southwest United States (AZ, CA, CO, NM, NV, UT)	10	13
Northeast United States (CT,DC,DE,IN,KY,MA,MD,NH, NJ,NY,OH,PA, RI,VA,VT,WV)	19	25
Southeast United States (AL,AR,FL,LA,MS,NC,OK,SC, TX,TN)	14	18
Canada	8	10
Mexico	0	--
Other (Please specify the Country) – *Denmark, United Arab Emirates, Dominican Republic, Puerto Rico*	5	7

Table 6 (continued)

Demographic Information of the Delphi Panel Experts

	N	Percent
6. Please rate your level of expertise in the field of Lean Manufacturing.		
1-Very Low	--	--
2-Low	--	--
3-Medium	21	29
4-High	36	49
5-Very High	19	22
7. How many years of lean manufacturing related work experience do you have?		
0 to 5 years	17	22
6 to 10 years	24	32
11 to 15 years	19	25
15 to 20 years	4	5
More than 20 years	12	16
8. Please indicate your level of commitment to serve as an expert on the Delphi panel and complete all three rounds of Delphi Study.		
1-Very Low	--	--
2-Low	--	--
3-Medium	21	28
4-High	36	47
5-Very High	19	25

Response Rates, Mean Standard Deviations,

and Coefficient of Variation of Questionnaire Rounds

The following sections will present the response rates, mean standard deviations, and Coefficient of Variation (CV) obtained from each round of Delphi questionnaire.

Response Rate

To identify experts for possible membership on Delphi panel, the pre-Delphi Web survey was sent to approximately 6000 subjects, out of which 138 responded to the study. Based on the pre-Delphi survey results, 102 experts were selected for Round One of the Delphi study, 76 of whom responded to the study. Table 7 presents the response rate obtained from each round of the study.

Table 7

Response Rates from Three Rounds of Delphi Study

Delphi Rounds	Sent	Received	Response Rate in Percentage
Round One	102	74	73%
Round Two	76	60	79%
Round Three	76	57	75%

Round One was sent to 102 participants; 74 responses were received, making the response rate 73.3%. At the close of Round One, the panel members selected to be a part of the study that did not respond to the Round One questionnaire were contacted. An email was sent to these members to identify their interest in pursuing the study as a panel member. Based on their level of interest in further participation, 76 panel members were culled from the Delphi panel for subsequent Delphi rounds.

Moreover, response rates were noted with respect to how many responses were received on a particular date for each round of the study. Figure 2 shows the responses received for Round One of the study. Round One was sent out on January 22, 2007. Three follow-up reminders were sent at an interval of 10-14 days, i.e. on February 2nd, 13th, and March 2nd. The first reminder was sent as an email to all the panelists, the second reminder was sent as a postcard to panelists residing in the United States, and the third reminder was sent as an email in all the three Delphi rounds. Figure 2 shows a graph that was plotted to depict the number of responses received on a particular date. The vertical lines in the graph represent the dates when a reminder was sent. As seen from the figure, it can be noted that the response rate increased after each reminder was sent.
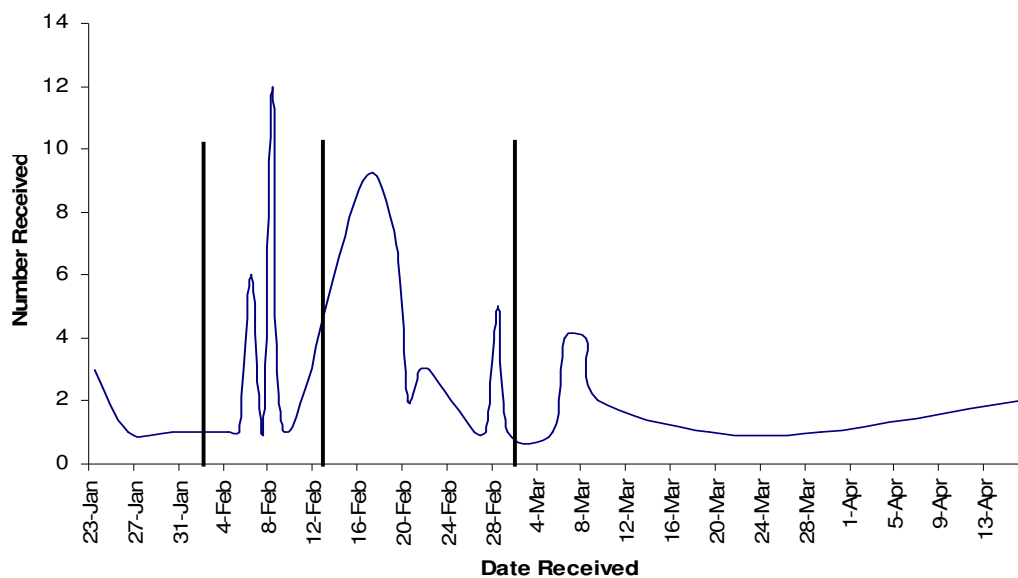
Figure 2. Response rate from Round One (reminders were sent on February 2, 13, and March 2).

Figure 3 illustrates the responses received from Round Two of the study. The graph below presents dates when responses were received on the X-axis and the number of responses received on the Y-axis. The vertical lines depict that the three reminders were sent on April 2, April 12, and April 27. Round Two was sent out on March 19, 2007. Due to the three reminders sent, Round Two yielded a response rate of approximately 79%.
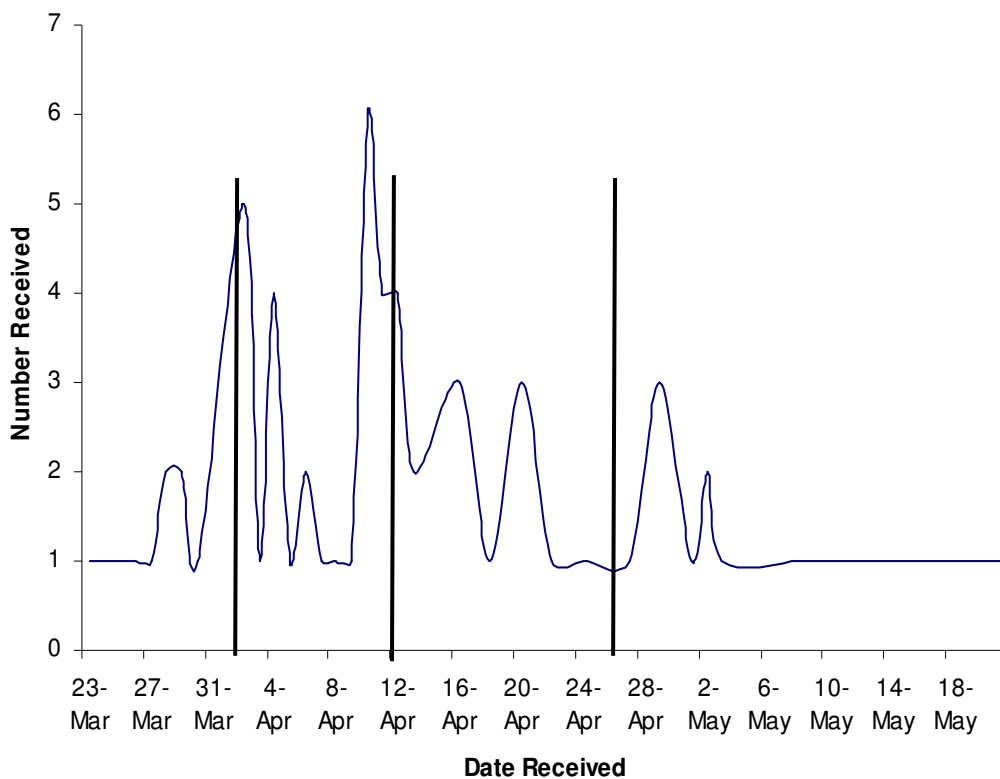
Figure 3. Response rate from Round Two (reminders were sent on April 2, 12, and 27).

Similarly, Figure 4 indicates a graph of the responses received from Round Three of the study. Round Three was sent out on May 10, 2007. The vertical lines on the graph show that three reminders were sent May 21, June 11, and June 26, at an interval of approximately 2 weeks. It can be seen from the graph that the number of survey responses received increased significantly after each reminder was sent. A response rate of 75% was achieved with the help of three follow-ups with the Delphi panel experts.
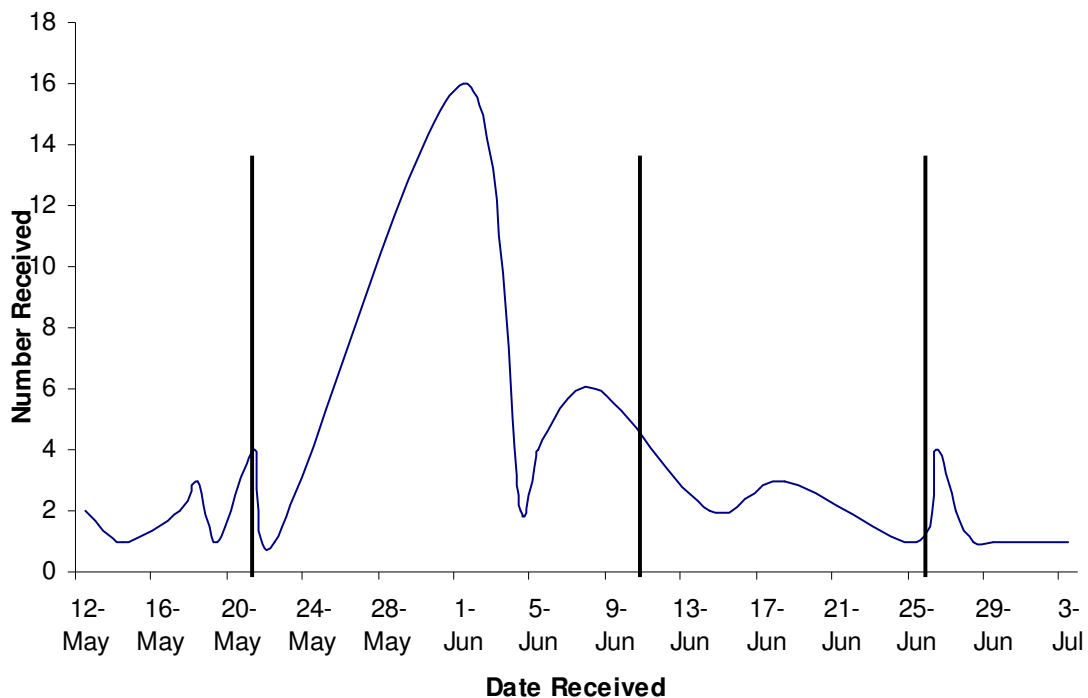
Figure 4. Response rate from Round Three (reminders were sent on May 21, June 11, and June 26).

Figure 5 shows an average response rate received across all three rounds of the Delphi study. From the graph, it can be noted that an average of ten responses were received once a survey was sent out. After the first reminder was sent, the response rate increased significantly. The first follow-up reminder yielded more responses than the second and third reminders. Collectively, based on Figure 2 (p. 75), Figure 3 (p. 76), Figure 4 (p. 77), and Figure 5, it can be concluded that the three follow-ups with the participants helped to improve the response rate in this Delphi study.
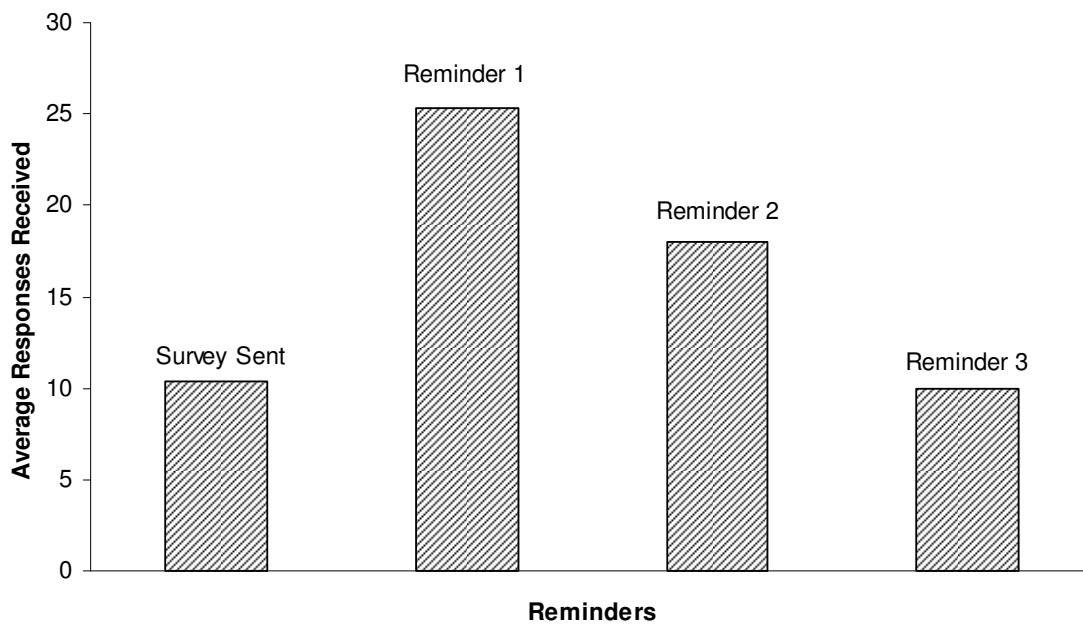
Figure 5. Average response rate across three Delphi rounds

Mean Standard Deviation

Mean standard deviation of competency areas was calculated for each round of the study across each level of examination, i.e., Bronze, Silver, and Gold. Table 8 shows values of these mean standard deviations. It can be seen from the table that the mean values of the standard deviations decreased for each examination level as the Delphi rounds progressed, indicating a convergence of opinion for each Delphi round.

Table 8

Mean Standard Deviation from the Three Rounds of Delphi Study for each Examination Level

Mean Standard Deviation Values			
Round	Bronze	Silver	Gold
One	0.7923	0.6690	0.6323
Two	0.6462	0.5178	0.5394
Three	0.6000	0.4660	0.4401

Coefficient of Variation

To check if reliability was obtained at the end of Round Three, Coefficient of Variation (CV) was calculated by dividing the standard deviation value from each competency area by its mean. An absolute difference of the CV values obtained from Rounds Two and Three was analyzed. Based on the literature, an absolute value of less than 0.8 indicates that stability has been obtained.

Table 9 (pp. 85-86) shows the value of CV obtained for each competency area at the Bronze exam level. The mean CV values for Round Two and Three were 0.35 and 0.33, respectively. A CV value of less than 0.8 for each of the competency areas at the Bronze level indicated that three rounds of questionnaire were enough and no more were required.

Table 9

Coefficient of Variance (CV) Values Obtained for the Bronze Level

Competency Areas	Round 2 Bronze CV=SD/Mean	Round 3 Bronze CV=SD/Mean	Diff. in CV =CVR2 - CVR3
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	0.3070	0.3128	(0.0058)
1.1.2. Respect for Humanity and Social Responsibility	0.5794	0.5667	0.0128
1.1.3. Long and Short-term Planning	0.2317	0.2446	(0.0129)
1.1.4. Principles of Lean leadership	0.0641	0.0472	0.0169
1.1.5. Lean Corporate Culture	0.1848	0.1311	0.0538
1.2.1. Principles of Empowerment	0.2976	0.3050	(0.0074)
1.2.2. Employee training and development	0.3714	0.2529	0.1184
1.2.3. Teamwork	0.2602	0.2866	(0.0265)
1.2.4. Suggestion/Feedback/Appraisal System	0.3326	0.2698	0.0628
1.2.5. Employee Turnover, Absenteeism, and Compensation	0.5700	0.6298	(0.0598)
1.2.6. Ergonomic, clean and safe work environment, and results	0.1769	0.1195	0.0574
Motivation Theory	0.3995	0.4080	(0.0085)
Socio-technical Systems	0.6057	0.5093	0.0964
2.1.1. Operational Vision and Strategy	0.3104	0.2613	0.0491
2.2.1 Product Design and Development	0.3350	0.3583	(0.0233)
2.2.2. Product Market Service	0.5570	0.5347	0.0223
2.3.1. Suppliers	0.3246	0.3175	0.0071
2.3.2 Customers	0.4962	0.5543	(0.0581)
2.3.3. Distribution & Transport Alliances	0.3168	0.3232	(0.0064)
2.4.1. Systematic identification and elimination of waste	0.0641	0.0890	(0.0249)
2.4.2. Just-in-Time Operations	0.0835	0.0742	0.0093
2.4.3. Cellular & Continuous Flow	0.0777	0.0662	0.0115
2.4.4. Lean Tools for Continuous Improvement	0.0908	0.1031	(0.0123)
Six Sigma/Problem Solving Techniques	0.4601	0.3707	0.0894
Quantitative Decision-Making Techniques	0.5114	0.3854	0.1260
Simulation Technique	0.6223	0.6518	(0.0294)
Optimization Techniques	0.5632	0.6017	(0.0385)
Facilities Design and Layout	0.2178	0.3173	(0.0994)

Table 9 (continued)

Coefficient of Variance (CV) Values Obtained for the Bronze Level

Competency Areas	CV=SD/Mean	CV=SD/Mean	Diff. in CV =CVR2 - CVR3
3.1.1 Administrative Vision & Strategy	0.2463	0.2720	(0.0257)
3.1.2. Alignment & Systematic Business & Service Process Design	0.3115	0.3312	(0.0196)
Supply Chain Logistics	0.3341	0.3351	(0.0010)
Lean Accounting	0.5492	0.5739	(0.0246)
Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	0.4235	0.4094	0.0141
4.1.1 Quality Results	0.1355	0.1176	0.0178
4.2.1 Cost & Productivity Results	0.1263	0.1676	(0.0413)
4.3.1 Delivery and Customer Service Measurement	0.2891	0.2129	0.0762
International Organization for Standardization (ISO) and Lean	0.4777	0.3944	0.0833
Quality Management System (QMS)	0.3995	0.3668	0.0326
5.1.1 Customer Satisfaction Results	0.3511	0.3505	0.0006
5.2.1. Profitability Measurement	0.6268	0.5307	0.0961
Lean Business Metrics	0.3505	0.2719	0.0785
Total Supply Chain Cost	0.6159	0.5669	0.0490

Table 10 (pp. 87-88) depicts the Coefficient of Variation values for the

Silver level of examination. The mean CV values for Round Two and Three were

0.19 and 0.17, respectively. An analysis of the difference in CV values from

Rounds Two and Three demonstrates that reliability of responses was achieved

at the end of Round Three.

Table 11 (pp. 88-89) below presents CV values obtained at the end of

Round Three for the Gold level. The mean CV value for Round Two was 0.15

and that for Round Three was 0.12. Therefore, the differences in CV values from

the two rounds indicated that stability of responses was attained, entailing that no

further rounds of the study were required.

Table 10

Coefficient of Variance (CV) Values Obtained for the Silver Level

Competency Areas	Round 2 Silver CV=SD/Mean	Round 3 Silver CV=SD/Mean	Silver Diff. in CV =CVR2 - CVR3
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	0.1399	0.0612	0.0787
1.1.2. Respect for Humanity and Social Responsibility	0.3175	0.3462	(0.0287)
1.1.3. Long and Short-term Planning	0.1310	0.1270	0.0039
1.1.4. Principles of Lean leadership	0.0456	0.0000	0.0456
1.1.5. Lean Corporate Culture	0.0835	0.0485	0.0350
1.2.1. Principles of Empowerment	0.1419	0.1489	(0.0069)
1.2.2. Employee training and development	0.1407	0.1265	0.0141
1.2.3. Teamwork	0.1016	0.1080	(0.0064)
1.2.4. Suggestion/Feedback/Appraisal System	0.1778	0.1574	0.0204
1.2.5. Employee Turnover, Absenteeism, and Compensation	0.2705	0.2881	(0.0176)
1.2.6. Ergonomic, clean and safe work environment, and results	0.0908	0.0570	0.0338
Motivation Theory	0.1944	0.2536	(0.0592)
Socio-technical Systems	0.2399	0.2253	0.0146
2.1.1. Operational Vision and Strategy	0.1764	0.1561	0.0203
2.2.1 Product Design and Development	0.1566	0.1520	0.0046
2.2.2. Product Market Service	0.2190	0.2354	(0.0165)
2.3.1. Suppliers	0.1464	0.1423	0.0041
2.3.2 Customers	0.1997	0.2237	(0.0241)
2.3.3. Distribution & Transport Alliances	0.1679	0.1369	0.0310
2.4.1. Systematic identification and elimination of waste	0.0557	0.0580	(0.0023)
2.4.2. Just-in-Time Operations	0.0456	0.0339	0.0117
2.4.3. Cellular & Continuous Flow	0.0456	0.0337	0.0119
2.4.4. Lean Tools for Continuous Improvement	0.0456	0.0470	(0.0014)
Six Sigma/Problem-Solving Techniques	0.3144	0.2327	0.0817
Quantitative Decision-Making Techniques	0.3426	0.2218	0.1208
Simulation Technique	0.3555	0.3238	0.0316
Optimization Techniques	0.3614	0.3401	0.0213
Facilities Design and Layout	0.2463	0.2212	0.0251

Table 10 (continued)

Coefficient of Variance (CV) Values Obtained for the Silver Level

3.1.1 Administrative Vision & Strategy	0.1374	0.1107	0.0267
3.1.2. Alignment & Systematic Business & Service Process Design	0.1802	0.1827	(0.0025)
Supply Chain Logistics	0.1868	0.1632	0.0236
Lean Accounting	0.2399	0.2243	0.0156
Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	0.3400	0.2494	0.0906
4.1.1 Quality Results	0.1228	0.0949	0.0279
4.2.1 Cost & Productivity Results	0.0557	0.0662	(0.0105)
4.3.1 Delivery and Customer Service Measurement	0.1370	0.1203	0.0166
International Organization for Standardization (ISO) and Lean	0.3031	0.2969	0.0062
Quality Management System (QMS)	0.3306	0.2545	0.0760
5.1.1 Customer Satisfaction Results	0.1663	0.1632	0.0031
5.2.1. Profitability Measurement	0.2640	0.2083	0.0557
Lean Business Metrics	0.1990	0.1825	0.0166
Total Supply Chain Cost	0.2353	0.2282	0.0071

Table 11

Coefficient of Variance (CV) Values Obtained for the Gold Level

Competency Areas	Round 2 Gold CV=SD/Mean	Round 3 Gold CV=SD/Mean	Gold Diff. in CV
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	0.0327	0.0000	0.0327
1.1.2. Respect for Humanity and Social Responsibility	0.1823	0.2080	(0.0258)
1.1.3. Long and Short-term Planning	0.0463	0.0570	(0.0106)
1.1.4. Principles of Lean leadership	0.1179	0.0000	0.1179
1.1.5. Lean Corporate Culture	0.0324	0.0000	0.0324
1.2.1. Principles of Empowerment	0.1300	0.0656	0.0643
1.2.2. Employee training and development	0.1406	0.0656	0.0749
1.2.3. Teamwork	0.0915	0.0586	0.0329
1.2.4. Suggestion/Feedback/Appraisal System	0.0959	0.0861	0.0098

Table 11 (continued)

Coefficient of Variance (CV) Values Obtained for the Gold Level

Competency Areas	CV=SD/Mean	CV=SD/Mean	Diff. in CV
1.2.5. Employee Turnover, Absenteeism, and Compensation	0.2014	0.2288	(0.0273)
1.2.6. Ergonomic, clean and safe work environment, and results	0.1263	0.0570	0.0693
Motivation Theory	0.1420	0.1742	(0.0321)
Socio-technical Systems	0.2215	0.1796	0.0419
2.1.1. Operational Vision and Strategy	0.0860	0.0570	0.0290
2.2.1 Product Design and Development	0.0894	0.0853	0.0041
2.2.2. Product Market Service	0.1375	0.1122	0.0253
2.3.1. Suppliers	0.1164	0.0729	0.0435
2.3.2 Customers	0.0840	0.0853	(0.0013)
2.3.3. Distribution & Transport Alliances	0.1196	0.1165	0.0030
2.4.1. Systematic identification and elimination of waste	0.1263	0.0477	0.0786
2.4.2. Just-in-Time Operations	0.0908	0.0890	0.0018
2.4.3. Cellular & Continuous Flow	0.1828	0.1211	0.0617
2.4.4. Lean Tools for Continuous Improvement	0.1606	0.0729	0.0877
Six Sigma/Problem Solving Techniques	0.3418	0.2388	0.1030
Quantitative Decision-Making Techniques	0.3041	0.2003	0.1039
Simulation Technique	0.3000	0.2836	0.0164
Optimization Techniques	0.2870	0.2938	(0.0068)
Facilities Design and Layout	0.1374	0.2101	(0.0728)
3.1.1 Administrative Vision & Strategy	0.0712	0.0470	0.0242
3.1.2. Alignment & Systematic Business & Service Process Design	0.1249	0.0915	0.0335
Supply Chain Logistics	0.1620	0.1130	0.0490
Lean Accounting	0.1826	0.1303	0.0523
Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	0.3128	0.1922	0.1206
4.1.1 Quality Results	0.0456	0.1069	(0.0613)
4.2.1 Cost & Productivity Results	0.0727	0.0882	(0.0156)
4.3.1 Delivery and Customer Service Measurement	0.1070	0.1106	(0.0036)
International Organization for Standardization (ISO) and Lean	0.2814	0.2296	0.0518
Quality Management System (QMS)	0.2949	0.2522	0.0427
5.1.1 Customer Satisfaction Results	0.1201	0.1086	0.0115
5.2.1. Profitability Measurement	0.1675	0.0982	0.0693
Lean Business Metrics	0.1512	0.1505	0.0007
Total Supply Chain Cost	0.1523	0.1707	(0.0184)

Results on Importance and Overall Quality of the Study

Table 12 contains results based on the additional questions asked

regarding the importance and overall quality of the study in the Round Three

questionnaire. The majority of the Delphi panel experts indicated that the results

of this study were either of very high or high importance to the field of Lean

manufacturing. Moreover, predominant responses for the overall quality of the

study ranged from very high to high.

Table 12

Results on Importance and Overall Quality of the Study from Round Three

	Very				*Very*	
	High	*High*	*Medium*	*Low*	*Low*	TOTAL
	5	*4*	*3*	*2*	*1*	
Importance of the results of this study to the field of Lean manufacturing	36%	57%	2%	3%	2%	53
Overall Quality of study	32%	51%	15%	2%	0%	53

Prioritized List of Competency Areas

A list of prioritized competency areas for Lean Bronze, Silver, and Gold

level examination based on mean and standard deviation scores is given in the

Tables 13 (pp. 89-90), 14 (pp. 91-92), and 15 (pp. 93-94). The competency areas

have been grouped under each domain and are categorized by low and high

standard deviations. The competency areas in bold and asterisks (*) represent

high mean and low standard deviation (higher degree of consensus among panel members), and those not in bold represent lower degree of agreement among panel members with either high or low mean values. Y% represents the "Yes" percentage of responses obtained from the "Necessary for Certification Exam?" question. Raw scores for each level of examination with frequency, mean, yes percentage rating, mean, and standard deviation values for the pre-Delphi, Round One, Two, and Three are presented in Appendices J, K, L, and M, respectively.

Table 13

Prioritized List of Competency Areas from the Lean Bronze Certification Level

Competency Areas	Mean	SD	Y%
I. ENABLERS FOR LEAN			
*1.1.4. Principles of Lean leadership	3.96	0.187	100
*1.2.6. Ergonomic, clean and safe work environment, and results	3.79	0.453	98.2
*1.1.5. Lean Corporate Culture	3.09	0.405	96.2
1.2.3. Teamwork	2.39	0.685	92.3
*1.2.2. Employee training and development	2.21	0.559	81.8
1.2.1. Principles of Empowerment	2.21	0.674	82.1
*1.2.4. Suggestion/Feedback/Appraisal System	2.05	0.553	81.8
*1.1.3. Long and Short-term Planning	2.04	0.499	81.5
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	1.95	0.61	15.8
Motivation Theory	1.75	0.714	10.7
1.1.2. Respect for Humanity and Social Responsibility	1.29	0.731	9.1
Socio-technical Systems	1.18	0.601	5.5
1.2.5. Employee Turnover, Absenteeism, and Compensation	1.14	0.718	1.8
II. LEAN CORE OPERATIONS			
*2.4.3. Cellular & Continuous Flow	3.93	0.26	100
*2.4.2. Just-in-Time Operations	3.91	0.29	100
*2.4.1. Systematic identification and elimination of waste	3.91	0.348	98.1

Table 13 (continued)

Prioritized List of Competency Areas from the Lean Bronze

Certification Level

*2.4.4. Lean Tools for Continuous Improvement	**3.86**	**0.398**	**100**
2.3.1. Suppliers	2.23	0.708	23.2
*2.1.1. Operational Vision and Strategy	**2.04**	**0.533**	**10.7**
2.2.1 Product Design and Development	2.04	0.731	27.3
Facilities Design and Layout	1.91	0.606	25
Six Sigma/Problem Solving Techniques	1.84	0.682	14.5
Quantitative Decision-Making Techniques	1.78	0.686	15.1
2.3.3. Distribution & Transport Alliances	1.77	0.572	7.3
2.3.2 Customers	1.4	0.776	14.3
2.2.2. Product Market Service	1.21	0.647	7.1
Optimization Techniques	1.18	0.71	5.4
Simulation Technique	1.14	0.743	7.3
III. BUSINESS CORE OPERATIONS – SUPPORT FUNCTIONS			
*3.1.1 Administrative Vision & Strategy	**2.07**	**0.563**	**83.9**
Supply Chain Logistics	1.91	0.64	7.3
3.1.2. Alignment & Systematic Business & Service Process Design	1.86	0.616	5.5
Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	1.8	0.737	9.4
Lean Accounting	1.34	0.769	9.1
IV. QUALITY, COST & DELIVERY MEASURES			
*4.1.1 Quality Results	**3.8**	**0.447**	**100**
*4.2.1 Cost & Productivity Results	**3.77**	**0.632**	**98.2**
*4.3.1 Delivery and Customer Service Measurement	**2.79**	**0.594**	**89.1**
Quality Management System (QMS)	1.96	0.719	14.8
International Organization for Standardization (ISO) and Lean	1.79	0.706	7.3
V. BUSINESS RESULTS			
Lean Business Metrics	1.96	0.533	41.1
5.1.1 Customer Satisfaction Results	1.96	0.687	12.7
5.2.1. Profitability Measurement	1.4	0.743	18.9
Total Supply Chain Cost	1.3	0.737	5.6

Table 14

Prioritized List of Competency Areas from the Lean Silver Certification Level

Competency Areas	Mean	SD	Y%
I. ENABLERS FOR LEAN			
*1.1.4. Principles of Lean leadership	**4.00**	**0.000**	**100.0**
*1.1.5. Lean Corporate Culture	**3.96**	**0.192**	**100.0**
*1.2.6. Ergonomic, clean and safe work environment, and results	**3.95**	**0.225**	**100.0**
*1.2.3. Teamwork	**3.89**	**0.420**	**100.0**
*1.2.2. Employee training and development	**3.09**	**0.391**	**100.0**
1.2.1. Principles of Empowerment	3.07	0.457	98.2
*1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	**3.04**	**0.186**	**98.0**
1.1.3. Long and Short-term Planning	2.96	0.376	98.1
1.2.4. Suggestion/Feedback/Appraisal System	2.96	0.466	96.4
Motivation Theory	2.74	0.695	85.7
Socio-technical Systems	2.53	0.570	71.4
1.1.2. Respect for Humanity and Social Responsibility	2.12	0.734	25.9
1.2.5. Employee Turnover, Absenteeism, and Compensation	2.02	0.582	17.9
II. LEAN CORE OPERATIONS			
*2.4.3. Cellular & Continuous Flow	**3.98**	**0.134**	**100.0**
*2.4.2. Just-in-Time Operations	**3.98**	**0.135**	**100.0**
*2.4.4. Lean Tools for Continuous Improvement	**3.96**	**0.186**	**100.0**
*2.4.1. Systematic identification and elimination of waste	**3.95**	**0.229**	**100.0**
*2.2.1 Product Design and Development	**3.04**	**0.462**	**96.4**
Facilities Design and Layout	3.02	0.668	94.6
2.1.1. Operational Vision and Strategy	2.96	0.462	100.0
*2.3.1. Suppliers	**2.93**	**0.417**	**96.4**
*2.3.3. Distribution & Transport Alliances	**2.82**	**0.386**	**90.9**
Quantitative Decision-Making Techniques	2.80	0.621	79.6
Six Sigma/Problem Solving Techniques	2.75	0.640	83.6
2.3.2 Customers	2.74	0.613	91.1
2.2.2. Product Market Service	2.68	0.631	78.2
Simulation Technique	2.39	0.774	54.5
Optimization Techniques	2.07	0.704	32.1

Table 14 (continued)

Prioritized list of Competency Areas from the Lean

Silver Certification Level

III. BUSINESS CORE OPERATIONS – SUPPORT FUNCTIONS			
***3.1.1 Administrative Vision & Strategy**	**3.09**	**0.342**	**100.0**
***3.1.2. Alignment & Systematic Business & Service Process Design**	**2.89**	**0.528**	**94.5**
Supply Chain Logistics	2.88	0.470	90.9
Lean Accounting	2.63	0.590	80.0
Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	2.39	0.596	83.0
IV. QUALITY, COST & DELIVERY MEASURES			
***4.2.1 Cost & Productivity Results**	**3.93**	**0.260**	**100.0**
***4.1.1 Quality Results**	**3.89**	**0.369**	**98.1**
***4.3.1 Delivery and Customer Service Measurement**	**3.79**	**0.456**	**98.2**
Quality Management System (QMS)	2.75	0.700	85.2
International Organization for Standardization (ISO) and Lean	2.27	0.674	67.3
V. BUSINESS RESULTS			
***Lean Business Metrics**	**3.02**	**0.551**	**98.2**
***5.1.1 Customer Satisfaction Results**	**2.88**	**0.470**	**92.7**
5.2.1. Profitability Measurement	2.77	0.577	88.7
Total Supply Chain Cost	2.77	0.632	81.8

Table 15

Prioritized List of Competency Areas from the Lean Gold Certification Level

Competency Areas	Mean	SD	Y%
I. ENABLERS FOR LEAN			
*1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	**4.00**	**0.000**	**100**
*1.1.4. Principles of Lean leadership	**4.00**	**0.000**	**98.2**
*1.1.5. Lean Corporate Culture	**4.00**	**0.000**	**100**
*1.1.3. Long and Short-term Planning	**3.95**	**0.225**	**100**
*1.2.6. Ergonomic, clean and safe work environment, and results	**3.95**	**0.225**	**100**
*1.2.3. Teamwork	**3.94**	**0.231**	**100**
1.2.1. Principles of Empowerment	3.93	0.258	100
1.2.2. Employee training and development	3.93	0.258	100
1.2.4. Suggestion/Feedback/Appraisal System	3.88	0.334	100
Motivation Theory	3.72	0.648	96.4
1.2.5. Employee Turnover, Absenteeism, and Compensation	3.37	0.771	91.1
1.1.2. Respect for Humanity and Social Responsibility	3.36	0.699	92.7
Socio-technical Systems	3.18	0.571	94.5
II. LEAN CORE OPERATIONS			
*2.4.1. Systematic identification and elimination of waste	**3.96**	**0.189**	**96.3**
*2.1.1. Operational Vision and Strategy	**3.95**	**0.225**	**100**
*2.3.1. Suppliers	**3.91**	**0.285**	**100**
*2.4.4. Lean Tools for Continuous Improvement	**3.91**	**0.285**	**96.4**
*2.4.2. Just-in-Time Operations	**3.91**	**0.348**	**96.3**
*2.2.1 Product Design and Development	**3.88**	**0.331**	**100**
*2.3.2 Customers	**3.88**	**0.331**	**100**
2.4.3. Cellular & Continuous Flow	3.88	0.470	98.2
*2.2.2. Product Market Service	**3.77**	**0.423**	**94.6**
2.3.3. Distribution & Transport Alliances	3.75	0.437	98.2
Facilities Design and Layout	3.65	0.767	92.9
Quantitative Decision-Making Techniques	3.64	0.729	92.6
Six Sigma/Problem Solving Techniques	3.48	0.831	90.9
Simulation Technique	2.86	0.811	74.5
Optimization Techniques	2.75	0.808	78.2

Table 15 (Continued)

Prioritized List of Competency Areas from the Lean Gold Certification Level

III. BUSINESS CORE OPERATIONS – SUPPORT FUNCTIONS			
*3.1.1 Administrative Vision & Strategy	**3.96**	**0.186**	**100**
*3.1.2. Alignment & Systematic Business & Service Process Design	**3.86**	**0.353**	**100**
*Supply Chain Logistics	**3.77**	**0.426**	**100**
Lean Accounting	3.73	0.486	100
Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	3.46	0.665	92.5
IV. QUALITY, COST & DELIVERY MEASURES			
*4.2.1 Cost & Productivity Results	**3.91**	**0.345**	**100**
*4.1.1 Quality Results	**3.89**	**0.416**	**94.4**
*4.3.1 Delivery and Customer Service Measurement	**3.88**	**0.429**	**98.2**
Quality Management System (QMS)	3.56	0.898	90.7
International Organization for Standardization (ISO) and Lean	3.38	0.776	90.9
V. BUSINESS RESULTS			
Lean Business Metrics	3.86	0.581	96.5
*5.1.1 Customer Satisfaction Results	**3.84**	**0.417**	**98.2**
*5.2.1. Profitability Measurement	**3.83**	**0.376**	**100**
Total Supply Chain Cost	3.75	0.640	98.2

An approach previously used by Tillman (1989) and Shah (2004) was used to group the competency areas into four major categories. Categories I and II contained Round Three mean ratings higher than 2.0, which implied higher-than-medium importance. Category I competency areas had lower standard deviation values, while Category II competency areas had higher standard deviation values. Categories III and IV contained other competency areas from

Round Three with mean ratings less than 2.0, which implied less-than-medium importance.

Category III competency areas had higher standard deviations, and Category IV had lower standard deviations.

Higher and lower values of standard deviations were determined based on the median value of standard deviation under each domain. In summary, the competency areas in:

Category I – High Mean Low Standard Deviation – should most likely be included.

Category II – High Mean High Standard Deviation – should likely be included.

Category III – Low Mean High Standard Deviation – should less likely be included.

Category IV – Low Mean Low Standard Deviation – should least likely be included.

Categorized Priority List for Bronze Level Examination

Tables 16-19 (pp. 96-99) present the prioritized list of competency areas obtained for the Bronze level of examination.

Table 16

Category I of Prioritized List of Competency Areas for Bronze with Round Three Means and Standard Deviations of Ratings

Competency Areas	Mean	SD	Y%
I. ENABLERS FOR LEAN			
1.1.4. Principles of Lean leadership	3.96	0.187	100
1.2.6. Ergonomic, clean and safe work environment, and results	3.79	0.453	98.2
1.1.5. Lean Corporate Culture	3.09	0.405	96.2
1.2.2. Employee training and development	2.21	0.559	81.8
1.2.4. Suggestion/Feedback/Appraisal System	2.05	0.553	81.8
1.1.3. Long and Short-term Planning	2.04	0.499	81.5
II. LEAN CORE OPERATIONS			
2.4.3. Cellular & Continuous Flow	3.93	0.26	100
2.4.2. Just-in-Time Operations	3.91	0.29	100
2.4.1. Systematic identification and elimination of waste	3.91	0.348	98.1
2.4.4. Lean Tools for Continuous Improvement	3.86	0.398	100
2.1.1. Operational Vision and Strategy	2.04	0.533	10.7
III. BUSINESS CORE OPERATIONS – SUPPORT FUNCTIONS			
3.1.1 Administrative Vision & Strategy	2.07	0.563	83.9
IV. QUALITY, COST & DELIVERY MEASURES			
4.1.1 Quality Results	3.8	0.447	100
4.2.1 Cost & Productivity Results	3.77	0.632	98.2
4.3.1 Delivery and Customer Service Measurement	2.79	0.594	89.1
V. BUSINESS RESULTS			
None			

Note: Category I indicates competency areas with high mean low standard deviation values meaning these areas should most likely be included.

Table 17

Category II of Prioritized List of Competency Areas for Bronze with Round Three Means and Standard Deviations of Ratings

Competency Areas	Mean	SD	Y%
I. ENABLERS FOR LEAN			
1.2.3. Teamwork	2.39	0.685	92.3
1.2.1. Principles of Empowerment	2.21	0.674	82.1
II. LEAN CORE OPERATIONS			
2.3.1. Suppliers	2.23	0.708	23.2
2.2.1 Product Design and Development	2.04	0.731	27.3
IV. QUALITY, COST & DELIVERY MEASURES			
None			
V. BUSINESS RESULTS			
None			

Note: Category II indicates competency areas with high mean high standard deviation values, meaning these areas should likely be included.

Table 18

Category III of Prioritized List of Competency Areas for Bronze with Round Three Means and Standard Deviations of Ratings

Competency Areas	Mean	SD	Y%
I. ENABLERS FOR LEAN			
Motivation Theory	1.75	0.714	10.7
1.1.2. Respect for Humanity and Social Responsibility	1.29	0.731	9.1
Socio-technical Systems	1.18	0.601	5.5
1.2.5. Employee Turnover, Absenteeism, and Compensation	1.14	0.718	1.8
II. LEAN CORE OPERATIONS			
Six Sigma/Problem Solving Techniques	1.84	0.682	14.5
Quantitative Decision-Making Techniques	1.78	0.686	15.1
2.3.2 Customers	1.4	0.776	14.3
2.2.2. Product Market Service	1.21	0.647	7.1
Optimization Techniques	1.18	0.71	5.4
Simulation Technique	1.14	0.743	7.3
III. BUSINESS CORE OPERATIONS – SUPPORT FUNCTIONS			
Supply Chain Logistics	1.91	0.64	7.3
Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	1.8	0.737	9.4
Lean Accounting	1.34	0.769	9.1
IV. QUALITY, COST & DELIVERY MEASURES			
Quality Management System (QMS)	1.96	0.719	14.8
International Organization for Standardization (ISO) and Lean	1.79	0.706	7.3
V. BUSINESS RESULTS			
5.2.1. Profitability Measurement	1.4	0.743	18.9
Total Supply Chain Cost	1.3	0.737	5.6

Note: Category III indicates competency areas with low mean high standard deviation values, meaning these areas should less likely be included.

Table 19

Category IV of Prioritized List of Competency Areas for Bronze with Round Three Means and Standard Deviations of Ratings

Competency Areas	Mean	SD	Y%
I. ENABLERS FOR LEAN 1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	1.95	0.61	15.8
II. LEAN CORE OPERATIONS Facilities Design and Layout	1.91	0.606	25
2.3.3. Distribution & Transport Alliances	1.77	0.572	7.3
III. BUSINESS CORE OPERATIONS – SUPPORT FUNCTIONS 3.1.2. Alignment & Systematic Business & Service Process Design	1.86	0.616	5.5
IV. QUALITY, COST & DELIVERY MEASURES None			
V. BUSINESS RESULTS Lean Business Metrics	1.96	0.533	41.1
5.1.1 Customer Satisfaction Results	1.96	0.687	12.7

Note: Category IV indicates competency areas with low mean low standard deviation values, meaning these areas should least likely be not included.

Categorized Priority List for Silver Level Examination

Table 20 (p. 100) and Table 21 (p. 101) present a categorized list of competency areas from Silver level examination. Please note that categorizes III and IV were absent for the Silver level.

Table 20

Category I of Prioritized List of Competency Areas for Silver with Round Three

Means and Standard Deviations of Ratings

Competency Areas	Mean	SD	Y%
I. ENABLERS FOR LEAN			
1.1.4. Principles of Lean leadership	4.00	0.000	100.0
1.1.5. Lean Corporate Culture	3.96	0.192	100.0
1.2.6. Ergonomic, clean and safe work environment, and results	3.95	0.225	100.0
1.2.3. Teamwork	3.89	0.420	100.0
1.2.2. Employee training and development	3.09	0.391	100.0
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	3.04	0.186	98.0
1.1.3. Long and Short-term Planning	2.96	0.376	98.1
II. LEAN CORE OPERATIONS			
2.4.3. Cellular & Continuous Flow	3.98	0.134	100.0
2.4.2. Just-in-Time Operations	3.98	0.135	100.0
2.4.4. Lean Tools for Continuous Improvement	3.96	0.186	100.0
2.4.1. Systematic identification and elimination of waste	3.95	0.229	100.0
2.2.1 Product Design and Development	3.04	0.462	96.4
2.3.1. Suppliers	2.93	0.417	96.4
2.3.3. Distribution & Transport Alliances	2.82	0.386	90.9
III. BUSINESS CORE OPERATIONS – SUPPORT FUNCTIONS			
3.1.1 Administrative Vision & Strategy	3.09	0.342	100.0
3.1.2. Alignment & Systematic Business & Service Process Design	2.89	0.528	94.5
Supply Chain Logistics	2.88	0.470	90.9
IV. QUALITY, COST & DELIVERY MEASURES			
4.2.1 Cost & Productivity Results	3.93	0.260	100.0
4.1.1 Quality Results	3.89	0.369	98.1
4.3.1 Delivery and Customer Service Measurement	3.79	0.456	98.2
V. BUSINESS RESULTS			
Lean Business Metrics	3.02	0.551	98.2
5.1.1 Customer Satisfaction Results	2.88	0.470	92.7

Note: Category I indicates competency areas with high mean low standard deviation values, meaning these areas should most likely be included.

Table 21

Category II of Prioritized List of Competency Areas, with Round III Means and

Standard Deviations of Ratings

Competency Areas	Mean	SD	Y%
I. ENABLERS FOR LEAN			
1.2.1. Principles of Empowerment	3.07	0.457	98.2
1.2.4. Suggestion/Feedback/Appraisal System	2.96	0.466	96.4
Motivation Theory	2.74	0.695	85.7
Socio-technical Systems	2.53	0.570	71.4
1.1.2. Respect for Humanity and Social Responsibility	2.12	0.734	25.9
1.2.5. Employee Turnover, Absenteeism, and Compensation	2.02	0.582	17.9
II. LEAN CORE OPERATIONS			
Facilities Design and Layout	3.02	0.668	94.6
2.1.1. Operational Vision and Strategy	2.96	0.462	100.0
Quantitative Decision-Making Techniques	2.80	0.621	79.6
Six Sigma/Problem Solving Techniques	2.75	0.640	83.6
2.3.2 Customers	2.74	0.613	91.1
2.2.2. Product Market Service	2.68	0.631	78.2
Simulation Technique	2.39	0.774	54.5
Optimization Techniques	2.07	0.704	32.1
III. BUSINESS CORE OPERATIONS – SUPPORT FUNCTIONS			
Lean Accounting	2.63	0.590	80.0
Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	2.39	0.596	83.0
IV. QUALITY, COST & DELIVERY MEASURES			
Quality Management System (QMS)	2.75	0.700	85.2
International Organization for Standardization (ISO) and Lean	2.27	0.674	67.3
V. BUSINESS RESULTS			
5.2.1. Profitability Measurement	2.77	0.577	88.7
Total Supply Chain Cost	2.77	0.632	81.8

Note: Category II indicates competency areas with high mean high standard deviation values, meaning these areas should likely be included.

Categorized Priority List for Gold Level Examination

Tables 22 (p. 102) and 23 (p. 103) indicate categories I and II from the Gold

examination level. Categories III and IV were not present at this level.

Table 22

Category I of Prioritized List of Competency Areas for Gold with Round Three

Means and Standard Deviations of Ratings

Competency Areas	Mean	SD	Y%
I. ENABLERS FOR LEAN			
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	4.00	0.000	100
1.1.4. Principles of Lean leadership	4.00	0.000	98.2
1.1.5. Lean Corporate Culture	4.00	0.000	100
1.1.3. Long and Short-term Planning	3.95	0.225	100
1.2.6. Ergonomic, clean and safe work environment, and results	3.95	0.225	100
1.2.3. Teamwork	3.94	0.231	100
II. LEAN CORE OPERATIONS			
2.4.1. Systematic identification and elimination of waste	3.96	0.189	96.3
2.1.1. Operational Vision and Strategy	3.95	0.225	100
2.3.1. Suppliers	3.91	0.285	100
2.4.4. Lean Tools for Continuous Improvement	3.91	0.285	96.4
2.4.2. Just-in-Time Operations	3.91	0.348	96.3
2.2.1 Product Design and Development	3.88	0.331	100
2.3.2 Customers	3.88	0.331	100
2.2.2. Product Market Service	3.77	0.423	94.6
III. BUSINESS CORE OPERATIONS – SUPPORT FUNCTIONS			
3.1.1 Administrative Vision & Strategy	3.96	0.186	100
3.1.2. Alignment & Systematic Business & Service Process Design	3.86	0.353	100
Supply Chain Logistics	3.77	0.426	100
IV. QUALITY, COST & DELIVERY MEASURES			
4.2.1 Cost & Productivity Results	3.91	0.345	100
4.1.1 Quality Results	3.89	0.416	94.4
4.3.1 Delivery and Customer Service Measurement	3.88	0.429	98.2
V. BUSINESS RESULTS			
5.1.1 Customer Satisfaction Results	3.84	0.417	98.2
5.2.1. Profitability Measurement	3.83	0.376	100

Note: Category I indicates competency areas with high mean low standard deviation values, meaning these areas should most likely be included.

Table 23

Category II of Prioritized List of Competency Areas for Gold with Round Three
Means and Standard Deviations of Ratings

Competency Areas	Mean	SD	Y%
I. ENABLERS FOR LEAN			
1.2.1. Principles of Empowerment	3.93	0.26	100
1.2.2. Employee training and development	3.93	0.26	100
1.2.4. Suggestion/Feedback/Appraisal System	3.88	0.33	100
Motivation Theory	3.72	0.65	96.4
1.2.5. Employee Turnover, Absenteeism, and Compensation	3.37	0.77	91.1
1.1.2. Respect for Humanity and Social Responsibility	3.36	0.70	92.7
Socio-technical Systems	3.18	0.57	94.5
II. LEAN CORE OPERATIONS			
2.4.3. Cellular & Continuous Flow	3.88	0.470	98.2
2.3.3. Distribution & Transport Alliances	3.75	0.437	98.2
Facilities Design and Layout	3.65	0.767	92.9
Quantitative Decision-Making Techniques	3.64	0.729	92.6
Six Sigma/Problem Solving Techniques	3.48	0.831	90.9
Simulation Technique	2.86	0.811	74.5
Optimization Techniques	2.75	0.808	78.2
III. BUSINESS CORE OPERATIONS – SUPPORT FUNCTIONS			
Lean Accounting	3.73	0.486	100
Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	3.46	0.665	92.5
IV. QUALITY, COST & DELIVERY MEASURES			
Quality Management System (QMS)	3.56	0.898	90.7
International Organization for Standardization (ISO) and Lean	3.38	0.776	90.9
V. BUSINESS RESULTS			
Lean Business Metrics	3.86	0.581	96.5
Total Supply Chain Cost	3.75	0.640	98.2

Note: Category II indicates competency areas with high mean high standard deviation values,
meaning these areas should likely be included.

Additional Comments by Delphi Panel Experts

A sample of some of the more cogent comments provided by Delphi
panel experts from Rounds One, Two, and Three are listed below. All other
additional comments made by the panelists can be found at the end of the

document. Results of Rounds One, Two, and Three are located in Appendices G, H, and I, respectively.

- *"Basic Lean elements should be known by all but not tested 3 times. Save question count at Gold level for broader topics. At Silver & Gold levels we need to test consumption VSM + Provision VSM = Entire VSM (See Lean Solutions)."*

- *"Having tried to master all the quantitative techniques available to support lean including simulation, optimization, RSM, non-linear Programming, etc.*
I think analysis to that level of sophistication should be left to subject matter experts. The lean practitioner needs to know these techniques exist and enough to know when to call in an expert though. Lean accounting, MRP and Supply-Chain expertise falls into that same category in my opinion. When one person has all the skills they are on overload! Spreading them around a team is good strategy!"

- *"The more you know, the more you can contribute! The bronze level should be exposed to everything that the silver and gold are using/need. Some is true of other levels in reflection to their complements. Tactical works inside the integration and strategic spheres."*

- *"As with all of the certification levels, the breadth and depth of knowledge should become more so. This should (might) include not only the topic of importance (by using the 5-point scale to rate the same) but also we could use the same 5-point scale to develop questions that have corresponding degrees of difficulty and knowledge. For example, for item 4.3.1, not only is it extremely important (a number rank of 4) for a Gold certificate holder's body of knowledge*

to know this information on customer service, but the degree of difficulty and depth of knowledge (with integrative skills) should be at a level of 4 too. This means that each certification level can get tested on the same topic but at different intellectual levels. In other words, I believe that all of these topic areas are important for each level of certification. I think, however, that the level of knowledge needed, and the relation to operational, tactical, or strategic strategy should be evaluated according to that level."

- "Bronze exam had too many "fuzzy (vague)" questions for a tactical level exam. I believe that Pascal Dennis's new book - 'Getting the Right Things Done' should be required reading for Silver & Gold levels. Gold portfolio should require at least one A3 project management document (with >= 3 months follow up data)."

- "One of the most important truths to "lean" is that the principles can be applied in many settings. Recently, organizations such as hospitals, governments, and banks have reported benefits from lean techniques. Though the methods are rooted in discrete manufacturing, I think there is an opportunity to be a little more inclusive of all environments, particularly in sections 2, 3, and 4."

- "The focus needs to be Lean and what it takes to be successful - Probably with more emphasis on implementation than tools, especially at Silver and Gold levels."

- "Gold & Silver seem redundant - merge into one - this seems supported by the responses. Bronze needs to know a lot even if "tested" on major implication skills/application specifics."

- "I think that most financial and accounting items can now be covered under a heading called lean accounting. Material on it is becoming more available. The cost accountants are finally beginning to take notice, too. The heading might not be called "Lean Accounting," however, but simply performance measurement. Doing so I think might make question writing on some of the rest of the exam easier. Dysfunctional or obsolete performance measures are a continuing impediment to lean, so this is very important.

. . . . . . Also in the present format it is difficult to indicate that the nature of questions on the same topics should be different at the different levels. Take this framework and break it into different levels, considering what should already be known to pass exams at the prior levels. That avoids redundancy when a limited number of questions can be prepped and taken at each level. More basic definition at the Bronze Level; operational integration at the Silver Level; and business or total enterprise integration at the Gold Level.

. . . . . .Another deficiency is that the human side of lean is still not fully recognized in the test. That becomes more important with advancing levels. It is becoming well-known that "Respect for People" and cultural change is vital to making lean an organizational way of life in which the techniques are embedded. It is not the way lean is now practiced in most organizations, but especially at the Gold Level, candidates should be aware of this."

- "Under 'Respect for Humanity' the positive impact of Lean must be effectively communicated to internal employees. There is a belief out there (by a few people) that 'Lean' means job loss - this belief must be changed and is an

important point under this category for the Bronze level."

- "Under 1.2.3.5 Team Dynamics are an important element and should have a higher score under the Bronze Category."

- "Level One - Bronze should focus on the understanding of the principles with some basic understanding on execution. Level Two - Silver needs to focus on the execution of the principles, Level Three - Gold should be more global in design to be used with the execution of other waste elimination strategies or it is redundant with Silver. Questions should evolve to a higher level of understanding for each level and not test over the same information."

In summary, it can be noted that the Delphi panel experts were enthusiastic in participating in the study and provided comments to improve the basic nature of Bronze, Silver, and Gold level examinations. Their remarks indicate that the three levels of examinations should focus on different cognitive levels such as knowledge, application, and judgment. The panelists seemed to be concerned about the redundancy of a few of the competency areas repeated in the body of knowledge. The Delphi panelists were interested in broadening the concept of lean so that it can be applied not only to the manufacturing sector but also to other areas such as health care, administrative departments, and so on.

A sample of additional comments made on the importance and/or quality of the study combined with suggestions for possible improvement are provided below:

- "By utilizing practicing professionals to develop the BOK, the result should yield content that is consistent with the needs of industry. I applaud your approach and

my only idea for improvement may be to drop the third round; it seemed unnecessary as most respondents had solidified their thoughts by the second round."

- "This study was well developed and was very comprehensive. This is a good model for overall business planning and execution."

- "This study is an important step in validating BOK. I don't know how influential the survey group is or how willing they are to use your findings. Good luck on your paper."

- "My interest in this survey/study has greatly increased since my professional developmental goal for this year is to obtain a Lean certification!!"

- "Paper copy was helpful (vs. on-line) because I did most responses on airplanes without my laptop. Not clear how responses will be used. Need bigger envelopes to return Reponses in."

- "I personally believe that to move from one level to the next there needs to be a "Dwell Time" in each step in which the candidates need to show that they are making progress or actually performing what they say and not just studying the answers."

- "Personally, the email version was easier to deal with than the mailed-copy version… but that's just me."

- "I feel the study was prepared very well and complete."

- "The study is the most comprehensive that I have ever seen in my career. I hope that it will serve to standardize and further Lean principles beyond the current narrow minded focus of cost cutting... ."

- *"I am concerned about the six sigma role/or lack of in this study. I have found that in order to sustain the improvements in the value stream you have to understand process capability, mean to failure, first pass yield, and standard deviation. You have to present a stable process/or environment to obtain and sustain the speed of lean. You must be able to use both tools to obtain world class satisfaction. I believe this is lacking in TQM (Lean/six sigma together)."*

- *"Somebody had to do this for us to know where to start."*

- *"Just a suggestion: this form allows the user to check all possible answer for one question, for instance the "necessary for the certification exam" you can check "yes" and "no" box at the same time. I know that most of the people involved will take care of this, but a "poka yoke" (like using option buttons instead of checkboxes) will be helpful."*

- *"I think the idea of certification is good especially at the Bronze and Silver levels. I agree with most of the comments about redundancy. I think the exams should get progressively more strategic in each competency so that there is no repeating information; each level should build on the one prior. Not much here on culture and how to change it. Focused more on the mechanisms than the philosophy. Overall, I think you are on the right track but the real value will be the depth of the curriculum and the actual application of principles to specific problems/situations to demonstrate competency, otherwise it will be a lot of knowledge that won't be applied."*

- *"The study is an important step toward formalizing training and accreditation in the principles and practices of Lean Manufacturing. Most of us have become*

involved in Lean Manufacturing through individual company training and

initiatives, driven by senior management vision. Results have been good, but

always capable of further improvement. More formal training will raise the profile

of Lean Manufacturing, hopefully to the extent that senior executives who have

not been exposed to the philosophies and approaches to Lean will become more

aware / committed to this as the strategic way forward in the global economy that

is the way of the modern world. I have been involved in Lean approaches in

large companies with high volume products in a narrow market (automotive), and

now at a mid-size privately owned contract manufacturer with low to high

volumes over a wide range of customers and market segments: the approaches

to Lean are more challenging in the latter field, but equally vital, and a nationally

recognized system of accrediting talent for Lean would be an asset in raising the

profile of Lean Manufacturing as a desirable goal for employee training."

- "I believe by having a breadth of people participating from various industries

and professions aids in developing an unbiased view of Lean and Lean

Certification expectations. Congratulations on taking this on, publishing the

results, etc."

- "As a Lean practitioner over the past 6 years, not having a valid certificate

demonstrating proficiency in Lean is a drawback. The industry needs an

effective method to document and certify individuals, and this study will enable a

robust standard to be set."

The comments on the importance and/or quality of the study indicate that

the panelists applauded this research effort and recognized that this study was

an important step to develop a standardized body of knowledge for the lean manufacturing discipline. The dichotomous type of response on ease of filling out the paper vs. email version of the questionnaire can also be noted from the comments. Moreover, the basic idea of having a lean certification was also appreciated by the panel members.

Recommended Body of Knowledge for

the SME/AME/Shingo Lean Certification Examination

An overall analysis to calculate the percentage of importance to each major domain in the body of knowledge was determined by a combined grand average of importance and "yes" percent ratings for each competency area within each domain. This approach is similar to the one used by Tillman (2000). Table 24 (p. 112) shows a comparison of the percent distribution for each domain for Bronze, Silver, and Gold level exams obtained from the Delphi study with the existing body of knowledge.

It can be seen from the table that Domains I and II were deemed to be more important than other Domains for Bronze level. The relative importance for Domains III and V increased as the level of exam progressed from Silver to Gold. Domain V had increased level of importance at Silver and Gold levels.

Table 24

Comparison of Percentage of Importance to each Major Domain obtained from the Delphi Study with the Existing Distribution in the Current Body of Knowledge

Domain	Bronze (Delphi)	Bronze (Current BOK)	Silver (Delphi)	Silver (Current BOK)	Gold (Delphi)	Gold (Current BOK)
I. Enablers for Lean	33.0%	15%	31.1%	25%	31.4%	35%
II. Lean Core Operations	35.7%	45%	35.8%	35%	35.1%	15%
III. Business Core Operations – Support Functions	9.1%	20%	11.1%	15%	12.0%	10%
IV. Quality, Cost & Delivery Measures	15.5%	15%	12.8%	10%	11.8%	10%
V. Business Results	6.7%	5%	9.2%	15%	9.7%	30%
TOTAL	100%		100%		100%	

A thorough analysis on which competency areas should be included in the body of knowledge under each level of examination was made by collating the comments as well as the categorized list of competency areas. The qualitative comments supplemented the quantitative analysis of mean and standard deviation values and were highly important in determining which competency areas are important enough to be included in the body of knowledge of the Lean certification program. Table 25 (pp. 113-118) presents a detailed recommended body of knowledge for each level of examination based on the results of the study.

The "*" in the table indicates that these competency areas were found to be necessary for the certification exam by the Delphi panelists. In few areas, a particular sub-competency or competencies were found to be of more importance for certain exam levels. For example, for the Bronze level, under 1.1.4. Principles of Lean leadership - 1.1.4.1 Go and See was suggested as the most important area for the exam.

Table 25

Recommended Body of Knowledge for the Lean manufacturing Certification Examination

	WEIGHTINGS PER EXAM		
	BRONZE (Tactical)	SILVER (Integrative)	GOLD (Strategic)
I. ENABLERS FOR LEAN	**33.0%**	**31.1%**	**31.4%**
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation 1.1.1.1 Business Vision 1.1.1.2 Business Mission 1.1.1.3 Business Purpose 1.1.1.4 Business Values, Philosophy, Ethics 1.1.1.5 Strategic Business Assessment 1.1.1.6 Strategy Development 1.1.1.7 Business Goals and Objectives 1.1.1.8 Core Competencies 1.1.1.9 Critical Success Factors	1.9%	* 2.4%	* 2.5%
1.1.2. Respect for Humanity and Social Responsibility 1.1.2.1 Schools and Communities 1.1.2.2 Unions 1.1.2.3 Other Stakeholders	1.2%	1.4%	* 2.2%
1.1.3. Long and Short-term Planning 1.1.3.1 Hoshin Planning & Policy Deployment 1.1.3.2 Execution and Metrics 1.1.3.3 Project Management	* 2.6%	* 2.4%	* 2.5%
1.1.4. Principles of Lean leadership 1.1.4.1 Go and See 1.1.4.2 Defining Value vs Non-value 1.1.4.3 Identifying Waste 1.1.4.4 Achieving Flow 1.1.4.5 Recognizing Normal vs Abnormal 1.1.4.6 Respect for Humanity	* 4.5% (1.1.4.1 *)	* 3.0%	* 2.5%
1.1.5. Lean Corporate Culture 1.1.5.1 Value Stream Mapping 1.1.5.2 Kaizen Blitz Events 1.1.5.3 Continuous Improvement & Change 1.1.5.4 Communication of Business Values, Philosophy, Ethics 1.1.5.5 Change & knowledge management systems 1.1.5.6 Resource Standards & Measures for Business Results	* 3.7% (1.1.5.1*, 1.1.5.2 *)	* 3.0%	* 2.5%

Table 25 (continued)

Recommended Body of Knowledge for the Lean manufacturing Certification Examination

	BRONZE (Tactical)	SILVER (Integrative)	GOLD (Strategic)
I. ENABLERS FOR LEAN			
1.2.1. Principles of Empowerment	* 2.7%	* 2.5%	* 2.5%
1.2.1.1 Communication			
1.2.1.2 Delegation			
1.2.1.3 Recognition			
1.2.1.4 Rewards			
1.2.1.5 Employee Satisfaction & Morale			
1.2.1.6 Employee & Labor Relations			
1.2.2. Employee training and development	* 2.7%	* 2.5%	* 2.5%
1.2.2.1 Instructional Goals			
1.2.2.2 Skills Assessment			
1.2.2.3 Continuous Learning Strategy			
1.2.2.4 Cross-Training			
1.2.2.5 Classroom and On-the-Job Training			
1.2.2.6 Coaching & Mentoring			
1.2.3. Teamwork	* 3.0%	* 3.0%	* 2.5%
1.2.3.1 Cross-Functional Team Selection & Leadership			
1.2.3.2 Multi-Level Participation			
1.2.3.3 Roles & Responsibilities			
1.2.3.4 Decision-Making Types			
1.2.3.5 Team Dynamics (Storming, norming, etc.)			
1.2.4. Suggestion/Feedback/Appraisal System	* 2.6%	* 2.4%	* 2.5%
1.2.4.1 Information Sharing			
1.2.5. Employee Turnover, Absenteeism, and Compensation	1.0%	1.3%	* 2.2%
1.2.6. Ergonomic, clean and safe work environment, and results	* 4.3%	* 3.0%	* 2.5%
1.2.6.1 Environment			
1.2.6.2 Ergonomics			
1.2.6.3 Safety			
Additional Areas from Pre-Delphi			
Motivation Theory	1.7%	* 2.2%	* 2.4%
Socio-technical Systems	1.1%	* 2.0%	* 2.1%

Table 25 (continued)

Recommended Body of Knowledge for the Lean manufacturing Certification Examination

	BRONZE 35.7%	SILVER 35.8%	GOLD 35.1%
II. LEAN CORE OPERATIONS			
2.1.1. Operational Vision and Strategy	* 1.9%	* 2.4%	* 2.5%
2.1.1.1 Operation Processes Vision, Mission, Strategy & Goals			
2.1.1.2 Lean Principles in Strategy			
2.1.1.3 Empowerment in Strategy			
2.1.1.4 Operational Alignment with Organizational Vision, Mission, Strategy & Goals			
2.2.1 Product Design and Development	* 2.1%	* 2.4%	* 2.5%
2.2.1.1 Quality Function Deployment			
2.2.1.2 Concurrent Engineering			
2.2.1.3 Variety Reduction			
2.2.1.4 Engineering Changes			
2.2.1.5 Design for Manufacture & Assembly			
2.2.1.6 Design for Product Life Cycle (DFx)			
2.2.1.7 Failure Mode & Effects Analysis (FMEA)			
2.2.1.8 Life Cycle Engineering			
2.2.1.9 Production Process Preparation (3P)			
2.2.1.10 Knowledge Transfer Methods & Practices			
2.2.2. Product Market Service	1.2%	* 2.1%	* 2.4%
2.2.2.1 Customer Feedback & Market Needs Analysis			
2.2.2.2 Customer Specs and Requirements	(2.2.2.2 *)		
2.2.2.3 New market development & current market exploitation			
2.2.2.4 E-commerce systems			
2.2.2.5 Benchmarking			
2.3.1. Suppliers	2.2%	* 2.4%	* 2.5%
2.3.1.1 Supplier Development Processes			
2.3.1.2 Supplier Certification			
2.3.1.3 Supplier Benchmarking			
2.3.1.4 Supplier Satisfaction Measures			
2.3.1.5 Corrective Action System			
2.3.2 Customers	* 1.4%	* 2.2%	* 2.5%
2.3.2.1 Customer Training & Development Processes			
2.3.2.2 Customer Selection Focus			
2.3.2.3 Demand Load Leveling	(2.3.2.3 *,		
2.3.2.4 Corrective Action System	2.3.2.4 *)		
2.3.3. Distribution & Transport Alliances	1.7%	* 2.3%	* 2.4%
2.3.3.1 Warehousing			
2.3.3.2 Distribution Centers			
2.3.3.3 Cross-Docks			
2.3.3.4 Reverse Logistics			
2.3.3.5 Remanufacturing/ Maintenance, Repair and Overhaul (MRO)			
2.3.3.6 Just-in-Time Alliances			
2.3.3.7 Supplier Managed Inventory Systems			

Table 25 (continued)

Recommended Body of Knowledge for the Lean manufacturing Certification Examination

	BRONZE (Tactical)	SILVER (Integrative)	GOLD (Strategic)
II. LEAN CORE OPERATIONS			
2.4.1. Systematic identification and elimination of waste	* 4.4%	* 3.0%	* 2.5%
2.4.1.1 Waste Identification and elimination of waste			
2.4.1.2 Value Stream Mapping			
2.4.1.3 Value Analysis			
2.4.1.4 5S Standards & Discipline			
2.4.1.5 Visual Workplace			
2.4.1.6 Kaizen Blitz Events			
2.4.1.7 Mistake Proofing			
2.4.1.8 Source Inspection			
2.4.1.9 Continuous Improvement			
2.4.1.10 Five Why's Problem Solving			
2.4.2. Just-in-Time Operations	* 4.4%	* 3.0%	* 2.5%
2.4.2.1 Takt Time			
2.4.2.2 Material Signals			
2.4.2.3 Pull System			
2.4.2.4 Continuous Flow			
2.4.2.5 Just-in-Time (JIT)			
2.4.2.6 Setup Reduction (SMED)			
2.4.2.7 Total Productive Maintenance (TPM)			
2.4.2.8 Load-Leveling (Heijunka)			
2.4.3. Cellular & Continuous Flow	* 4.4%	* 3.0%	2.5%
2.4.3.1 Cellular Manufacturing			
2.4.3.2 One Piece Flow			
2.4.3.3 Standard Work			
2.4.3.4 Multi-process Handling			
2.4.3.5 Autonomation			
2.4.3.6 Production Schedule			
2.4.3.7 Bills of Materials			
2.4.3.8 Routings			
2.4.3.9 Flow Analysis Charts			
2.4.4. Lean Tools for Continuous Improvement	* 4.4%	* 3.0%	* 2.5%
2.4.4.1 Plan-Do-Check-Act			
2.4.4.2 Reliability & maintainability			
2.4.4.3 Root Cause & Corrective Action			
2.4.4.4 Flow Charting			
2.4.4.5 Pareto			
2.4.4.6 Cause & effect Diagrams			
2.4.4.7 Check Sheets			
2.4.4.8 Histograms			
2.4.4.9 Scatter & Concentration Diagrams			
2.4.4.10 Control Charts			
2.4.4.11 Problem Solving Storyboards			

Table 25 (continued)

Recommended Body of Knowledge for the Lean manufacturing Certification Examination

	BRONZE	SILVER	GOLD
II. LEAN CORE OPERATIONS			
Additional Areas from Pre-Delphi			
Six Sigma/Problem Solving Techniques (merge with 2.4.4)	1.8%	2.2%	* 2.2%
Quantitative Decision-Making Techniques (merge with 2.4.4)	1.7%	2.2%	* 2.3%
Simulation Technique	1.1%	1.8%	1.8%
Optimization Techniques	1.1%	1.5%	1.8%
Facilities Design and Layout	1.9%	2.4%	* 2.3%
III. BUSINESS CORE OPERATIONS-SUPPORT FUNCTIONS	**9.1%**	**11.1%**	**12.0%**
3.1.1 Administrative Vision & Strategy	* 2.6%	* 2.5%	* 2.5%
3.1.1.1 Application of Lean principles & techniques			
3.1.1.2 Focus on value adds & waste identification & elimination			
3.1.1.3 Commitment to Continuous Improvement			
3.1.1.4 Business operations improvement metrics			
3.1.2. Alignment & Systematic Business & Service Process Design	1.7%	* 2.3%	* 2.5%
3.1.2.1 Finance & Accounting: Measurement & control systems,etc			
3.1.2.2 Human Resources: Alignment of selection, development, teamwork, performance feedback & discipline, compensation & rewards, etc.			
3.1.2.3 Materials Management:Inventory Control,planning&scheduling,logistics, etc			
3.1.2.4 Information Technology:Appropriate alignment with process changes, accessibility,etc			
3.1.2.5 Sales&Marketing:Alignment of sales&operations planning&execution,etc			
3.1.2.6 Quality Assurance: Regulation & certification, inspection rationale, etc			
3.2.1.7 Process & Manufacturing Engineering: System for engineering changes, concurrent process, etc			
3.2.1.8 Legal & Regulatory: Alignment with core lean thinking, etc			
Additional Areas from Pre-Delphi			
Supply Chain Logistics	1.8%	* 2.3%	* 2.4%
Lean Accounting	1.3%	* 2.1%	* 2.4%
Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	1.7%	2.0%	2.2%
IV. QUALITY, COST & DELIVERY MEASURES-	**15.5%**	**12.8%**	**11.8%**
4.1.1 Quality Results	* 4.3%	* 3.0%	* 2.4%
4.1.1.1 Rework			
4.1.1.2 Customer PPM Rejects			
4.1.1.3 First Pass Yield			
4.1.1.4 Scrap			
4.1.1.5 Process Variation			
4.1.1.6 Cost of Quality			
4.1.1.7 Warranty Costs			

Table 25 (continued)

Recommended Body of Knowledge for the Lean manufacturing Certification Examination

	BRONZE	SILVER	GOLD
4.2.1 Cost & Productivity Results	* 4.3%	* 3.0%	* 2.5%
4.2.1.1 Inventory Turns			
4.2.1.2 Record Accuracy			
4.2.1.3 Cycle Time, Takt Time and Throughput Time			
4.2.1.4 Operational Equipment Effectiveness (OEE)			
4.2.1.5 Labor Value-Add			
4.2.1.6 Product Cost Reduction			
4.2.1.7 Changeover			
4.2.1.8 Resource Utilization			
4.2.1.9 Energy Efficiency			
4.2.1.10 Performance to Load Leveling			
4.3.1 Delivery and Customer Service Measurement	* 3.3%	* 2.9%	* 2.5%
4.3.1.1 Line-Items Delivered On-Time to Customer Requirement			
4.3.1.2 Complete Orders Delivered On-Time to Customer Requirements			
4.3.1.4 Premium Freight			
4.3.1.5 Mistakes in Shipment			
4.3.1.6 Warranty Response, Service, etc.			
Additional Areas from Pre-Delphi			
International Organization for Standardization (ISO) and Lean *(Merge ISO and QMS)*	1.7%	1.8%	* 2.2%
Quality Management System (QMS) *(Merge ISO and QMS)*	1.9%	2.2%	* 2.3%
V. BUSINESS RESULTS	**6.7%**	**9.1%**	**9.7%**
5.1.1 Customer Satisfaction Results	1.9%	* 2.3%	* 2.4%
5.1.1.1 Market Share			
5.1.1.2 Reorder Rate			
5.1.1.3 Customer Survey Results			
5.1.1.4 Customer Audit Results			
5.1.1.5 Other Customer Feedback			
5.1.1.6 Value/Improvement Analysis			
5.1.1.7 Customer Retention			
5.1.1.8 Customer Awards			
5.2.1. Profitability Measurement	* 1.4%	* 2.2%	* 2.4%
5.2.1.1 Operating Income on Sales & Assets			
5.2.1.2 Operating Income on Space			
5.2.1.3 Fixed & Variable Costs			
5.2.1.4 Cash Flow			
5.2.1.5 Value Stream Profitability			
Additional Areas from Pre-Delphi			
Lean Business Metrics *(Include under Lean Accounting)*	2.1%	* 2.4%	* 2.4%
Total Supply Chain Cost *(Include under Lean Accounting)*	1.2%	* 2.2%	* 2.4%

Note: * indicates the Delphi panel members suggested that these competency areas are necessary to be included on the certification exam

In addition to the above percentage of importance, based on the Delphi expert's comments, the following modifications are recommended to the lean body of knowledge:

1. Change the title of 1.1.2 Respect for Humanity and Social Responsibility to "Social Responsibility."

2. Under 1.1.4 Principles of Lean Leadership, add Motivation theory.

3. Competency 1.1.5 Lean corporate culture can be changed to "Lean tools, techniques, and culture" so that the title is consistent with the sub-competencies listed.

4. Include the additional area suggested – "Socio-technical Systems" – under 1.2.1 Principles of Empowerment.

5. The additional competency areas suggested – "Six Sigma" and "Quantitative Decision-Making Techniques" – can be merged with 2.4.4 Lean tools for continuous improvement.

6. The additional competency areas suggested – "ISO" and "Quality Management Systems" – should be merged into one area.

7. The additional competency areas suggested – "Lean Business Matrix" and "Total Supply Chain Cost" – should be included under "Lean Accounting."

Test Specifications

Based on the percentage domain distribution obtained from the Delphi study, the number of items covered under every domain that should appear on each level of examination was calculated. Bronze, Silver, and Gold level

examinations are set to contain 150 multiple-choice questions to be completed in a three-hour time-frame. The number of items on the test was determined by multiplying the percentage allocated to each domain with the total number of questions in each certification level. Table 26 shows the recommended test blueprint for Bronze, Silver, and Gold level of Lean certification exam along with a recommended change in terms of number of test items. The items below can be adjusted by the SME/AME/Shingo lean certification committee depending upon the percentage of competency areas under each domain that were deemed important or unimportant by the Delphi panel experts.

Table 26

Recommended Test Blueprint for Bronze, Silver, Gold Examination Levels

Domain	Bronze	# of Items on Test	Bronze Rec. Change (# of Items)	Silver	# of Items on Test	Silver Rec. Change (# of Items)	Gold	# of Items on Test	Gold Rec. Change (# of Items)
I. Enablers for Lean	33.00%	50	+28	31.10%	47	+10	31.40%	47	-6
II. Lean Core Operations	35.70%	54	-14	35.80%	54	+2	35.10%	53	+31
III. Business Core Operations – Support Functions	9.10%	14	-16	11.10%	17	-6	12.00%	18	+3
IV. Quality, Cost & Delivery Measures	15.50%	23	+1	12.80%	19	+4	11.80%	18	+3
V. Business Results	6.70%	10	+3	9.20%	14	-9	9.70%	15	-30
TOTAL	100%	150		100%	150		100%	150	

CHAPTER V. RESULTS, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

The qualitative and quantitative results of the study are summarized in this chapter. The recommended body of knowledge for the lean manufacturing certification program is based on the ratings of importance of competency areas by the Delphi panel experts and their comments. Conclusions and recommendations for future research can be found at the end of the chapter.

Results

The purpose of this role delineation study was to validate and prioritize the competency areas in the body of knowledge used for creating the test blue prints for the three levels of examination for the Lean certification examination developed by a consortium of Society of Manufacturing Engineers, Association for Manufacturing Excellence, and Shingo Prize for Excellence in Manufacturing. From the results of the Web-based pre-Delphi study, 76 panel members were selected to serve on the Delphi panel for three rounds of questionnaires. The demographic information collected in the pre-Delphi round indicated that the majority of the experts were in the age range of 35-54, with most having a Master's degree. About 44% of the respondents possessed at least one professional certification or license. The majority of them were either at a senior management or mid-management level, while only 5% were college or university faculty. Almost 17% of the panel members were located outside the United States. Their self-rating of the level of expertise in the field of lean manufacturing

ranged from medium to very high, with the majority rating themselves as having a high level of expertise. Moreover, a large number of experts had a minimum of 6 to 10 years of experience related to lean.

The panel of experts participated through three iterations of Delphi questionnaires in both mail and electronic format, rated competency areas, and offered many valuable comments. Additional competency areas suggested from the pre-Delphi study were added to the Round One questionnaire. The three rounds of the study had response rates of approximately 73%, 79%, and 75%. Additional questions were asked in Round Three to rate the importance and overall quality of the study. A large number of the Delphi panel experts indicated that the results of this study were either of very high or high importance to the field of Lean manufacturing. Moreover, predominant responses for the overall quality of the study ranged from very high to high.

A prioritized list of competency areas under each domain for different certification levels was created based on mean and standard deviation ratings. This categorized list, along with the comments from the Delphi experts, provided a basis for determining the inclusion of a particular competency area on the certification exam. A combined grand average of mean and yes percent rating determined the percent of importance for each domain.

The results of the study enable the main research questions of the study, as originally stated in Chapter I, to be answered as follows:

1. What content/competency areas do the experts think should be included in the three lean manufacturing certification examinations?

The competency areas suggested by the Delphi panel experts to be included on the lean manufacturing certification examination can be seen from the recommended body of knowledge obtained through the study. The competencies were prioritized, categorized, and incorporated in the body of knowledge taking their comments into consideration (see Table 25).

2. What percentage of importance should be allocated to each major category (domain) in the body of knowledge?

The percentage of importance to be allocated to each major domain in the body of knowledge was determined by a combined grand average of mean and "yes" percent rating. Such an analysis was performed for each level of examination, and a percentage of importance was obtained. Significant differences in the weightage were evident in Domain I and III for the Bronze level, Domain I and V for Silver, and Domain II and V for the Gold level examinations (see Tables 24 and 25).

3. How many items should be present under each domain of the body of knowledge on the exam?

A test blueprint was developed by multiplying the percentage of importance to each domain with the total number of questions that will appear for each certification level. Thus, the number of items that should be present under each domain of the body of knowledge was determined (see Table 26).

4. What is the difference in the body of knowledge delineated in SME's prototype BOK and that found through this study?

A side-by-side tabular comparison of the percentage of importance

assigned to each domain in the current body of knowledge and that through the study delineated the differences (see Table 24). Moreover, recommendations were provided to make modifications to the body of knowledge based on the results of the study (see pp. 119-120).

Conclusions

This role delineation study was conducted to refine the body of knowledge and enable validation of the test blue prints for the SME/AME/Shingo lean manufacturing certification examinations. A Delphi technique with both qualitative and quantitative components was used to collect data and obtain feedback and suggestions from experts in the field of lean manufacturing. The comments provided by the Delphi panelists combined with the quantitative analysis of the results helped to validate the body of knowledge and determine the test specifications for the Bronze, Silver, and Gold levels of lean certification examinations.

It is noteworthy to recognize the high level of professionalism of the panel of experts who participated in the study, exemplified through their prompt and thorough responses. The comments and ratings provided by these experts were a good indication of the fact that the study was of high importance for the lean manufacturing discipline and that it was also of high quality.

The SME/AME/Shingo lean certification committee should use the recommendations and the results obtained as a baseline to modify their current body of knowledge and to revise the certification examination. It should be noted

that there is a possibility that the importance of higher level competency areas may have been rated artificially high because of the level of expertise and years of experience of the members of the Delphi panel.

The results of the study can be applied to establish a standardized body of knowledge of the lean manufacturing discipline. Moreover, the results of the study can help to guide training, curriculum development, and future growth and development in other areas of lean manufacturing.

Recommendations

Although the test specifications outlined in this study provide an estimate of how many items should be present under each domain, it is recommended that the lean certification committee should create a more specific test specification table based on the importance of each competency area within each domain. An appropriate judgment can be applied to incorporate the additional competency areas suggested by the Delphi panelists from the research. It is also recommended that for making a sound decision, the certification committee should look at the qualitative comments provided by the experts for each competency area and also their additional comments. These comments add meaning to the statistical results.

The test specifications should also show cognitive domain (knowledge, application, judgment) and difficulty (low, medium, high) levels assigned to each competency area for every level of certification. An item analysis of the actual certification exam should be conducted to assure the validity and reliability of the

exam. Thus, the lean certification examination should be revised to reflect the

changes suggested by the Delphi panel experts through this study.

Further, such a study should be conducted at an interval of every 5 to 7

years to keep up with the developments in the field and to meet the needs of

industry.

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Appendices

Appendix A

BODY OF KNOWLEDGE FOR

SME/AME/ SHINGO LEAN MANUFACTURING CERTIFICATION PROGRAM

VERSION 2.0, MARCH 2006

Lean Certification
Body of Knowledge

(Version 2.0, March 2006)

LEAN CERTIFICATION
BODY OF KNOWLEDGE RUBRIC VERSION 1.0

	WEIGHTINGS PER EXAM		
	Lean Bronze (tactical)	Lean Silver (integrative)	Lean Gold (strategic)
MODULE 1			
1. ENABLERS FOR LEAN	15%	25%	35%
1.1. Leadership	5%	10%	15%
1.1.1. Business vision, mission, values, strategies and goals, including resource allocation.			
1.1.1.1. Business Vision			
1.1.1.2. Business Mission			
1.1.1.3. Business Purpose			
1.1.1.4. Business Values, Philosophy, Ethics			
1.1.1.5. Strategic Business Assessment (external evaluation)			
1.1.1.6. Strategy Development			
1.1.1.7. Business Goals and Objectives			
1.1.1.8. Core Competencies			
1.1.1.9. Critical Success Factors			
1.1.1.10. Resource Allocation			
1.1.2. Respect for Humanity and Social Responsibility			
1.1.2.1. Schools and Communities			
1.1.2.2. Unions			
1.1.2.3. Other Stakeholders			
1.1.3. Long and Short-term Planning			
1.1.3.1. Hoshin Planning and Policy Deployment			
1.1.3.2. Execution and Metrics			
1.1.3.3. Project Management			
1.1.4. Principles of Lean leadership			
1.1.4.1. Go and See (Genchi Genbutsu)			
1.1.4.2. Defining Value Versus Non-value			
1.1.4.3. Identifying Waste			
1.1.4.4. Achieving Flow			
1.1.4.5. Recognizing Normal Versus Abnormal			
1.1.4.6. Respect for Humanity			
1.1.5. Lean corporate culture			
1.1.5.1. Value Stream Mapping			
1.1.5.2. Kaizen Blitz Events			
1.1.5.3. Continuous Improvement and Change			
1.1.5.4. Communication of Business Values, Philosophy, Ethics			
1.1.5.5. Change and knowledge management systems			
1.1.5.6. Resource Standards and Measures for Business Results			
1.2. Empowerment and Human Development	10%	15%	20%
1.2.1. Principles of empowerment			
1.2.1.1. Communication			
1.2.1.2. Delegation			
1.2.1.3. Recognition			
1.2.1.4. Rewards			
1.2.1.5. Employee Satisfaction and Morale			

	WEIGHTINGS PER EXAM		
	Lean Bronze (tactical)	Lean Silver (integrative)	Lean Gold (strategic)
1.2.1.6. Employee and Labor Relations			
1.2.2.Employee Training and Development			
1.2.2.1. Instructional Goals			
1.2.2.2. Skills Assessment			
1.2.2.3. Continuous Learning Strategy			
1.2.2.4. Cross-Training			
1.2.2.5. Classroom and On-the-Job Training			
1.2.2.6. Coaching and Mentoring			
1.2.3.Teamwork			
1.2.3.1. Cross-Functional Team Selection and Leadership			
1.2.3.2. Multi-Level Participation			
1.2.3.3. Roles and Responsibilities			
1.2.3.4. Decision-Making (types of decision making, e.g. consensus)			
1.2.3.5. Team Dynamics (storming, norming, forming, team relations, etc.)			
1.2.4.Suggestion/Feedback/Appraisal System			
1.2.4.1. Information Sharing (Yokoten)			
1.2.5.Employee turnover, absenteeism and compensation			
1.2.6.Ergonomic, clean and safe work environment and results			
1.2.6.1. Environment			
1.2.6.2. Ergonomics			
1.2.6.3. Safety			
MODULE 2			
2. LEAN CORE OPERATIONS	45%	35%	15%
2.1. Operational Vision and Strategy	2%	5%	7%
2.1.1.Operational Vision and Strategy			
2.1.1.1. Operational Processes Vision, Mission, Strategy, and Goals			
2.1.1.2. Lean Principles in Strategy			
2.1.1.3. Empowerment in Strategy			
2.1.1.4. Operational Alignment with Organizational Vision, Mission, Strategy, and Goals			
2.2. Innovations in Product Design and Market Service	8%	12%	5%
2.2.1.Product Design and Development (product/service)			
2.2.1.1. Quality Function Deployment (QFD)			
2.2.1.2. Concurrent or Simultaneous Engineering			
2.2.1.3. Variety Reduction			
2.2.1.4. Engineering Changes			
2.2.1.5. Design for Manufacture and Assembly			
2.2.1.6. Design for Product Life Cycle (DFx) (cradle to cradle)			
2.2.1.7. Failure Mode and Effects Analysis			
2.2.1.8. Life Cycle Engineering			
2.2.1.9. Production Process Preparation (3P)			
2.2.1.10. Knowledge Transfer Methods & Practices			
2.2.2.Product Market Service			
2.2.2.1. Customer Feedback and Market Needs Analysis			
2.2.2.2. Customer Specs and Requirements			
2.2.2.3. New market development and current market exploitation			

	WEIGHTINGS PER EXAM		
	Lean Bronze (tactical)	Lean Silver (integrative)	Lean Gold (strategic)
2.2.2.4. E-commerce systems			
2.2.2.5. Benchmarking			
2.3. Suppliers and Customers (relationship development)	3%	10%	3%
2.3.1.Suppliers			
2.3.1.1. Supplier Development Processes			
2.3.1.2. Supplier Certification			
2.3.1.3. Supplier Benchmarking			
2.3.1.4. Supplier Satisfaction Measures			
2.3.1.5. Corrective Action System			
2.3.2.Customers			
2.3.2.1. Customer Training and Development Processes			
2.3.2.2. Customer Selection and Focus			
2.3.2.3. Demand Load Leveling			
2.3.2.4. Corrective Action System			
2.3.3.Distribution and Transport Alliances			
2.3.3.1. Warehousing			
2.3.3.2. Distribution Centers			
2.3.3.3. Cross-Docks			
2.3.3.4. Reverse Logistics (returns, dunnage, etc.)			
2.3.3.5. Remanufacturing / Maintenance, Repair and Overhaul (MRO)			
2.3.3.6. Just-in-Time Alliances			
2.3.3.7. Supplier Managed Inventory Systems			
2.4. Core Operations & Processes	32%	8%	0%
2.4.1.Systematic identification and elimination of waste			
2.4.1.1. Waste Identification and Elimination (7+ wastes)			
2.4.1.2. Value Stream Mapping			
2.4.1.3. Value Analysis			
2.4.1.4. 5S Standards and Discipline			
2.4.1.5. Visual Workplace			
2.4.1.6. Kaizen Blitz Events			
2.4.1.7. Mistake / Error Proofing (Poka-Yoke)			
2.4.1.8. Quality at the Source / Source Inspection			
2.4.1.9. Continuous Improvement (Kaizen)			
2.4.1.10. 5–Why's Problem Solving			
2.4.2.Just-in-Time Operations			
2.4.2.1. Takt Time			
2.4.2.2. Material Signals (Kanban)			
2.4.2.3. Pull System			
2.4.2.4. Continuous Flow			
2.4.2.5. Just-in-Time (JIT)			
2.4.2.6. Quick Changeover/Setup reduction (SMED)			
2.4.2.7. Total Productive/Preventative/Predictive Maintenance (TPM)			
2.4.2.8. Load-Leveling (Heijunka)			
2.4.3. Cellular and Continuous Flow			
2.4.3.1. Cellular Manufacturing			
2.4.3.2. One Piece Flow			
2.4.3.3. Standard Work (operator instructions, etc.)			
2.4.3.4. Multi-Process Handling (multiple machines operating simultaneously)			
2.4.3.5. Autonomation (Jidoka)			
2.4.3.6. Production Schedule			
2.4.3.7. Bills of Material			

	WEIGHTINGS PER EXAM		
	Lean Bronze (tactical)	Lean Silver (integrative)	Lean Gold (strategic)
2.4.3.8. Routings			
2.4.3.9. Flow Analysis Charts (spaghetti diagrams, man-machine, etc.)			
2.4.4.Lean Tools for Continuous Improvement			
2.4.4.1. Plan-Do-Check-Act (PDCA) (DMAIC)			
2.4.4.2. Reliability and maintainability			
2.4.4.3. Root Cause and corrective action			
2.4.4.4. Flowcharting			
2.4.4.5. Pareto			
2.4.4.6. Cause and effect diagrams (Fishbone)			
2.4.4.7. Check Sheets			
2.4.4.8. Histograms			
2.4.4.9. Scatter and Concentration Diagrams			
2.4.4.10. Control Charts (includes SPC)			
2.4.4.11. Problem Solving Storyboards			
MODULE 3			
3. BUSINESS CORE OPERATIONS - SUPPORT FUNCTIONS	20%	15%	10%
3.1. Administrative Vision and Strategy in Finance and Accounting, Human Resources, Materials Management, Information Technology, Sales and Marketing, Quality Assurance, Process & Manufacturing Engineering and Legal & Regulatory	20%	15%	10%
3.1.1.The BOK in this section is analogous to Module 2, it applies to business and service processes			
3.1.1.1. Application of lean principles and techniques			
3.1.1.2. Focus on value adds and waste identification and elimination			
3.1.1.3. Commitment to Continuous Improvement			
3.1.1.4. Business operations improvement metrics			
3.1.2.Alignment and Systematic Business and Service Process Design			
3.1.2.1. Finance and Accounting: measurement and control systems, etc.			
3.1.2.2. Human Resources: alignment of selection, development, teamwork, performance feedback and discipline, compensation and rewards, regulations, etc.			
3.1.2.3. Materials Management: inventory control, planning and scheduling, procurement, logistics, material handling, etc.			
3.1.2.4. Information Technology: appropriate alignment with process changes, accessibility, flexibility to change, etc.			
3.1.2.5. Sales and Marketing: alignment of sales and operations planning and execution, product rationalization, customer interaction, etc.			
3.1.2.6. Quality Assurance: regulation and certification, inspection rationale, feedback, quality improvement system, etc.			
3.1.2.7. Process & Manufacturing Engineering: system for engineering changes, feedback for new product development, concurrent process, etc.			
3.1.2.8. Legal and Regulatory: alignment with core lean			

	WEIGHTINGS PER EXAM		
	Lean Bronze (tactical)	Lean Silver (integrative)	Lean Gold (strategic)
thinking, etc.			
MODULE 4			
4. QUALITY, COST & DELIVERY MEASURES	15%	10%	10%
4.1. Quality & Quality Improvement	5%	3%	0%
4.1.1. Quality Results			
4.1.1.1. Rework			
4.1.1.2. Customer PPM Rejects			
4.1.1.3. First Pass Yield			
4.1.1.4. Scrap (Internal PPM Rejects)			
4.1.1.5. Process Variation			
4.1.1.6. Cost of Quality			
4.1.1.7. Warranty Costs			
4.2. Cost and Productivity Improvement	5%	4%	4%
4.2.1. Cost and Productivity Results			
4.2.1.1. Inventory Turns			
4.2.1.2. Record Accuracy (inventory, bill of material, operator instructions, etc.)			
4.2.1.3. Cycle Time, Takt Time and Throughput Time			
4.2.1.4. Operational Equipment Effectiveness (OEE)			
4.2.1.5. Labor Value-Add			
4.2.1.6. Product Cost Reduction			
4.2.1.7. Changeover			
4.2.1.8. Resource Utilization			
4.2.1.9. Energy Efficiency			
4.2.1.10. Performance to Load Leveling (linearity in production)			
4.3. Delivery and Customer Service Improvement	5%	3%	6%
4.3.1. Delivery and Customer Service Measurement			
4.3.1.1. Line-Items Delivered On-Time to Customer Requirements			
4.3.1.2. Complete Orders Delivered On-Time to Customer Requirements			
4.3.1.3. Customer Lead Time			
4.3.1.4. Premium Freight			
4.3.1.5. Mistakes in Shipments			
4.3.1.6. Warranty Response, Service, etc.			
MODULE 5			
5. BUSINESS RESULTS	5%	15%	30%
5.1. Customer Satisfaction	3%	8%	15%
5.1.1. Customer Satisfaction Results			
5.1.1.1. Market Share			
5.1.1.2. Reorder Rate			
5.1.1.3. Customer Survey Results			
5.1.1.4. Customer Audit Results			
5.1.1.5. Other Customer Feedback			
5.1.1.6. Value / Improvement Analysis			
5.1.1.7. Customer Retention			
5.1.1.8. Customer Awards			
5.2. Business Results	2%	7%	15%
5.2.1. Profitability Measurement			
5.2.1.1. Operating Income on Sales and Assets			
5.2.1.2. Operating Income on Space			
5.2.1.3. Fixed and Variable Costs			

	WEIGHTINGS PER EXAM		
	Lean Bronze (tactical)	Lean Silver (integrative)	Lean Gold (strategic)
5.2.1.4. Cash Flow			
5.2.1.5. Value Stream Profitability			

Appendix B

LIST OF LEAN MANUFACTURING BOOKS USED FOR CONTENT ANALYSIS

Dennis, P. (2002). *Lean production simplified*. New York : Productivity Press.

Jordan, Jr., J.A., & Michel, F.J. (2001). *The lean company: Making the right choices*. Dearborn, MI: Society of Manufacturing Engineers.

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APPENDIX C

HUMAN SUBJECTS REVIEW COMMITTEE APPROVAL LETTER AND
RELATED DOCUMENTATION

EASTERN MICHIGAN UNIVERSITY
Graduate Studies and Research

Faculty/Doctoral Human Subjects Request for Approval Form

Submit 3 copies of this completed form and your proposal.

Date submitted _06/15/06____ Due Date of funding Proposal _____N/A_____

Principal Investigator _____Hiral Shah_____

Co-PI Project Director _____Dr. Tracy Tillman _____

Department __Ph.D. in Technology___ Telephone _____734-262-9853_____

E-Mail __hiral.shah@emich.edu_____ Fax _____

Title of Project _____A Role Delineation Study for Lean Manufacturing

Certification Examination_____

_____

From what sources are funds expected for this project? _____N/A_____

I.   Is this application New / Renewal / Modification _____New_____

         Will this project continue for more than one year (Yes/No) ____No_____

   If this is a renewal:

         Date of last approval by this committee: _____N/A_____

         Principal Investigator in previous research: _____N/A_____

         Describe any modifications to the previously approved research protocols.

                 N/A

         Were any human subject problems encountered in the previous research? If yes,

         how were they handled?

                 N/A

II.   If you are requesting an exemption from HSRC review, explain the statutory basis

        for the requested exemption.

        "1. Research conducted in established or commonly accepted educational
        settings, involving normal education practices;"

        "3.Research involving observation of public behavior or survey or interview
        procedures;
        a. Which does not place subjects at the risk of civil or criminal
        liability or be damaging to the subject's financial standing or employability,
        and
        b. Which does not deal with sensitive aspects of the subject's own
        behavior, such as illegal conduct, drug use, sexual behavior or use of
        alcohol, and
        c. Which does not use materials, procedures or settings likely to be
        embarrassing, upsetting or intrusive to- the subjects, and
        d. Where the subject cannot be identified and confidentiality is protected;"

        Extracted from:
        http://www.gradord.emich.edu/downloads/grad_files/grad_humansubjects/Human
        Sub_emupolicy.pdf

III.   Numbers, Types and Recruitment of Subjects

        A. Numbers and characteristics of subjects (e.g., age ranges, sex, ethnic

            background, health status, handicapping conditions, etc.):

        -   Number of subjects – Approx. 200

            Characteristics:
        -   Experience in Lean Manufacturing
        -   Self-rating of Expertise in Lean Manufacturing
        -   Commitment to serve on Delphi panel
        -   Members of Society of Manufacturing Engineers or Institute of Industrial
            Engineers

        B. Special Classes. Explain the rationale for the use of special classes or subjects

            such as pregnant women, children, prisoners, mentally impaired,

            institutionalized, or others who are likely to be particularly vulnerable.

            None

C. How is the individual subject to be recruited for this research? Is it clear to

the subjects that participation is voluntary and that they may withdraw at any

time without negative consequences?

- Organizations such as SME and IIE will be contacted and they will be

asked to provide the name of individuals who are interested in the field

of lean manufacturing.

- Yes. It is clear to the subjects that participation is voluntary and that they
may withdraw at any time without any negative consequences.

IV. Informed Consent

A. To what extent and how are the subjects to be informed of their research

procedures before their participation?

- The subjects will be informed of the research procedures in the cover
letter sent along with the questionnaire and their participation will be
voluntary. All data about their personal information will be kept confidential
and will be destroyed after the results of the research are obtained.

B. Attach a copy of the written "Informed consent form" or a written statement

of the oral consent.

- Attached

V. Risks involved in the Research

A. Does the research involve any of the following procedures (YES/NO)

Deception of the subject: _____NO_____

Punishment of the subject: _____NO_____

Use of drugs in any form: _____NO_____

Electric Shock: _____NO_____

Deliberate production of anxiety or stress: _____NO_____

Materials commonly regarded as socially unacceptable: ____NO_____

Use of radioisotopes: _____NO_____

Use of chemicals: _____NO_____

Drawing of blood: _____NO_____

B. Any other procedure that might induce in the subject any altered state or

condition potentially harmful to his/her personal welfare? (YES/NO)

_____NO_____.

C.   Any procedure that might be considered an invasion of privacy?

(YES/NO) _____NO_____.

Disclosure of name or individual research subjects? (YES/NO)

_____NO_____.

Any other physically invasive procedure? (YES/NO)

_____NO_____.

If the answer to any of the above is "Yes". Please explain this aspect of the procedure in detail.

D.   Describe the procedures for protecting against or minimizing any potential risk.

- The personal information of all the subjects will be kept confidential and will be destroyed once the research is completed.

VI.   Confidentiality

A.   To what extent is the information confidential and to what extent are provisions made so that subjects are not identified?

- All responses will be kept anonymous.

B.   What are the procedures for handling and storing al data so that confidentiality of the subjects is protected (particular attention should be given to the use of photographs, video and audio recordings)?

- The personal information of the subjects will be destroyed after the research is completed and results are obtained. The responses will be kept confidential.

- The names of the subjects on the Delphi Panel will not be disclosed to other members of the Delphi Panel. Personal information will be kept confidential and destroyed at the end of the research.

C. How will the results of the research be disseminated? Will the subjects be informed of the results? Will confidentiality of subjects or organizations be protected in the dissemination? Explain.

- Disseminated in the form of dissertation work, paper presentation and publications.
- Yes. The subjects be informed of the results
- Yes. The responses will be kept anonymous.

VII.   Describe any anticipated benefits to subjects from participation in this research.

- The subject will know the results of each round of Delphi study along with the qualitative comments from the respondents. The final results will also be provided to them. Participating in such a Delphi study will be an added credit to their professional experience since only the experts take part in such a study. Moreover, the results of this study will help them to identify the areas in which they may need focus in order to be successful in providing initiatives at a Lean company.

- The results of this study will be helpful to the Society of Manufacturing Engineers, Association for Manufacturing Excellence, and Shingo Prize to update their Lean manufacturing certification. The results will also help the schools that are planning to develop program in Lean manufacturing.

Attach a copy of the full proposal including copies of all instruments or tests to be used. If any instruments are not fully developed, attach drafts and so indicate.

Principal Investigator _____

(Signature)

Date: _____

Please print, sign and send 3 copies of this form and attachments to HSRC Administrative Co-Chair, Starkweather Hall.

Below are many of the elements that a faculty UHSRC reviewer will look for throughout the previous Request for Approval form, and the Consent Agreement. Please review this list as a guide in the preparation of your research proposal and informed consent.

Checklist of Required Elements of Informed Consent

Please add the following statement to the final copy of your Informed Consent Agreement, *"This research protocol has been reviewed and approved by the Eastern Michigan University Human Subjects Review Committee and if you have any questions on the approval process, please contact either Dr. Patrick Melia or Dr. Steven Pernecky at   734-487-0379."*

_____ A statement that the study involves research

_____ Purpose of the research

_____ Duration of subject's participation

_____ Description of the procedures followed

_____ Means of public dissemination

_____ Description of foreseeable risks or discomforts to subject

_____ Description of benefits to subject or to others

_____ Disclosure of appropriate alternative procedures or courses of treatment

_____ Statement of extent to which confidentiality of records identifying subject is

maintained

_____ Statement of how participant confidentiality is maintained in public dissemination

_____ For research of greater than minimal risk, information regarding medical

treatments or counseling should personal injury or problems occur

_____ List of contacts who can answer questions about the research and subject's

rights, and respond to research-related injury to subject

_____ Statement that participation is voluntary

_____ Statement that refusal to participate will involve no penalty or loss of benefits

_____ Statement that the subject may discontinue participation at any time

_____ Statements of significant new findings developed during the course of research

that may relate to subjects' willingness to continue participation

Provide Rationale for Exclusion of a Required Element:

INFORMED CONSENT FORM

Researcher's Name: Hiral Shah

Name and Address of Department: School of Engineering Technology, 118 Sill Hall, Ypsilanti, MI 48197

Email: hiral.shah@emich.edu

Name of University: Eastern Michigan University, Ypsilanti, MI 48197

Title of Research: A ROLE DELINEATION STUDY FOR LEAN MANUFACTURING CERTIFICATION EXAMINATION

Purpose of the Research: To identify the competency areas needed for Lean manufacturing certification exam and hence to update the body of knowledge (BOK) of Lean certification via a role delineation study.

Procedure of the research:

The current role delineation study will be conducted using a modified Delphi technique. This research will consist of a web based pilot survey followed by three rounds of mailed questionnaire to identify the competency areas in the Lean Manufacturing certification examination.

The participation in the study is voluntary. Participants can withdraw from the study any time. The data collected will be kept confidential. Personal information of the subjects will not be disclosed. Any data related to personal information will be destroyed once the results are obtained and research is completed.

I have read and understand that the participation in this study is voluntary and I can withdraw my participation from this research project at any time.

I consent to participate in this research activity.

☐ **Agree**   ☐**Disagree**

Hiral:

In an expedited review, reviewers found your human subjects proposal "A Role
Delineation Study for Lean Manufacturing Certification Examination" to be
exempt from UHSRC review.

However, reviewers felt strongly that your consent agreement should be
amended to include the following:

1. Statement of the means of public dissemination
2. Statement of description of foreseeable risks or discomfort to subjects
3. Description of the benefits to subjects or to others (beyond "great
contribution," add "improved certification processes" to motive
professionals in the field
4. List of contacts who can answer questions about the research and the
subject's rights
5. Statement that refusal to participate will involve no penalty or loss of
benefits
6. Assurance that data will be kept in a locked cabinet. State that
confidentiality will be maintained also in public dissemination
7. Estimate of time involved

One reviewer suggested adding the elements of the consent agreement to the
introductory letter that screens for expertise. As it is, this letter
contains more specific assurances than your consent agreement.

These are suggestions only -- not requirements. You are authorized to
continue your data collection without further UHSRC review.

If at some future point you make substantive changes to your protocol, you
will need once again to seek UHSRC approval.

Best wishes as you continue work on your dissertion, Hiral!

Bob

Robert Holkeboer, Ph.D.
Associate Vice President
Graduate Studies and Research
Eastern Michigan University
Ypsilanti, MI 48197
Phone (734) 487-0042
Fax (734) 487-0050
robert.holkeboer@emich.edu

EASTERN MICHIGAN UNIVERSITY

September 22, 2006

Hiral Shah
School of Engineering Technology

Dear Hiral:

The Human Subjects Institutional Review Board (IRB) of Eastern Michigan University has granted approval to your proposal, "A Role Delineation Study for Lean Manufacturing Certification Examination."

After careful review of your completion application, the IRB determined that the rights and welfare of the individual subjects involved in this research are carefully guarded. Additionally, the methods used to obtain informed consent are appropriate, and the individuals participating in your study are not at a risk.

You are reminded of your obligation to advise the IRB of any change in the protocol that might alter your research in any manner that differs from that upon which this approval is based. Approval of this project applies for one year from the date of this letter. If your data collection continues beyond the one-year period, you must apply for a renewal.

On behalf of the Human Subjects Committee, I wish you success in conducting your research.

Sincerely,

Deb de Laski-Smith, Ph.D
Interim Dean
Graduate School
Administrative Co-Chair
University Human Subjects Review Committee

Copy: Karen Saules, Faculty Co-Chair

APPENDIX D

FLYER TO ADVERTISE THE STUDY AT

THE ASSOCIATION FOR MANUFACTURING EXCELLENCE (AME)

CONFERENCE (OCT 16-21, 2006)

Your participation is extremely essential and will be greatly appreciated!

Lean Experts Wanted!!

For a research study to validate the

Body of Knowledge of the SME/AME/Shingo

Lean Manufacturing Certification Program.

If you are interested in participating in this important research as a *Delphi Panel Expert*, please complete the online survey or sign up at the SME booth.

** This study will involve a pre-Delphi online survey and three rounds of mailed questionnaire. It is a ground breaking study and first of its kind to validate the Body of Knowledge in the Lean Manufacturing field. Your responses will be kept confidential and used only in conjunction of this study.

Researcher: Ms. Hiral Shah, CEI, CEM
Doctoral Candidate at Eastern Michigan University
Email: hiral.shah@emich.edu
Ph: 734-262-9853
Online Survey Link: http://emuonline.info/surveys/predelphi.htm

You can make an important contribution to the field of Lean Manufacturing via this research effort.

Hiral Shah (hiral.shah@emich.edu)
Online Survey: http://emuonline.info/
surveys/predelphi.htm

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Online Survey: http://emuonline.info/
surveys/predelphi.htm

Appendix E

PRE-DELPHI QUESTIONNAIRE

Society of Manufacturing Engineers

WHERE MANUFACTURING COMES TOGETHER™

Dear :

We are looking forward to your participation as a Delphi panel expert in our study titled "A Role Delineation Study for the SME/AME/Shingo Lean Certification Program." The purpose of our study is to gather data to validate and prioritize the competency areas that form the body of knowledge for the lean manufacturing certification program developed jointly by the Society of Manufacturing Engineers (SME), Shingo Prize for Excellence (Shingo), and Association for Manufacturing Excellence (AME).

Your contribution to our study is most valued, and essential to assuring validity in this research and ultimately creating a standard for the Lean manufacturing discipline.

If you have not yet had a chance to complete the pre-Delphi questionnaire, please try to do so as soon as possible before November 15. **The survey can be accessed by clicking on the following link:**

http://www.emuonline.info/surveys/predelphi.htm
[This survey can be best viewed using Internet Explorer.]

If you feel that you are not qualified to participate, please pass this pre-Delphi survey questionnaire on to someone else in your organization that you feel is qualified.

Your valuable contribution via this research study can--and will--have a long-term effect on education, certification, and professional practice for our discipline. We very much appreciate your time, effort, and contribution.

Thank you in advance!
Sincerely,

Ms. Hiral Shah, Researcher   **Jeanine Kunz, Manager of Certification**
Eastern Michigan University   Society of Manufacturing Engineers

If you have any questions, please contact Hiral Shah at hiral.shah@emich.edu.

EASTERN MICHIGAN UNIVERSITY

INFORMED CONSENT FORM

Principal Researcher: Ms. Hiral A. Shah, CEI, CEM

Name of University: Eastern Michigan University, Ypsilanti, MI 48197

Name and Address of Department: School of Engineering Technology, 118 Sill Hall, Ypsilanti, MI 48197

Email: hiral.shah@emich.edu

Title of Research Study: A ROLE DELINEATION STUDY FOR THE SME/AME/SHINGO LEAN MANUFACTURING CERTIFICATION PROGRAM

Purpose of the Research: To identify and validate competency areas for the body of knowledge (BOK) for the Bronze, Silver, and Gold SME/AME/Shingo lean manufacturing certification examinations.

Procedure of the research:
This role delineation study will be conducted using a modified Delphi technique. The process of our Delphi study is delineated as follows:

1. Pre-Delphi survey (web based) – Wider opinion on possible topics to be included in the BOK is gathered from a large population of lean practitioners, managers, educators, and consultants. Lean experts are identified from this population and selected as Delphi panelists.
2. Round I (mailed questionnaire) – Delphi panel experts review the results of the Pre-Delphi survey and provide an expert-level rating of BOK topics, suggestions for additions/deletions, and additional comments.
3. Round II (mailed questionnaire) – Delphi panel experts review the results of Round I, provide a revised rating of BOK topics, suggestions for more additions/deletions, and additional comments.
4. Round III (mailed questionnaire) – Delphi panel experts review the results of Round II, provide a final revised rating of BOK topics, suggestions for final additions/deletions, and concluding comments. All Delphi panelists will receive the final results of the study.

Please consider taking approximately 15-20 minutes to complete our questionnaire, to assure that we attain good quality results. Your participation in the study is voluntary, and very much appreciated. Participants can withdraw from the study any time. The data collected will be held in the strictest confidence in a locked file of the Principal Researcher. Personal information of the subjects will not be disclosed. Any data related to personal information will be destroyed once the results are obtained and the research is completed. Confidentiality will be maintained throughout public dissemination of the results via my dissertation, and other published articles or papers.

If you have any further questions regarding the consent agreement and research protocol approval procedures, you may contact Dr. Steve Pernecky or Dr. Patrick Melia, who are Co-Chairs of the Eastern Michigan University Human Subjects Review Committee at 734-487-0379.

I have read and understand that the participation in this study is voluntary and I can withdraw my participation from this research project at any time without any penalty or loss of benefits. I consent to participate in this research activity.

| | ○ | Agree |

Demographic Questions

1. What is your age group?

- ○ Under 25
- ○ 25 to 34
- ○ 35 to 44
- ○ 45 to 54
- ○ 55 to 64
- ○ 65+

2. What is the highest level of education that you have completed?

- ○ High School
- ○ Associate Degree
- ○ Bachelor's Degree
- ○ Master's Degree
- ○ Doctorate
- ○ Other (Please specify): _____

3. Which of the following engineering-related professional designations do you hold?

- ☐ CEI
- ☐ CEM
- ☐ PE
- ☐ CMfgE
- ☐ CMfgT
- ☐ None
- ☐ Other (Please specify): _____

4. Which of the following most closely describes your current position within your organization?

○	Senior Management
○	Mid-level Management
○	Consulting/Private Practice
○	College/University Faculty
○	Design/Engineering
○	Manufacturing/Operations/Quality/Support
○	Other (Please specify):

5. Which of the following best describes the place of your residence?

○	Northcentral United States (IA, IL, KS, MI, MN, MO, NE, ND, SD, WI)
○	Northwest United States (ID, MT, OR, WA, WY)
○	Southwest United States (AZ, CA, CO, NM, NV, UT)
○	Northeast United States (CT, DC, DE, IN, KY, MA, MD, ME, NH, NJ, NY, OH, PA, RI, VA, VT, WV)
○	Southeast United States (AL, AR, FL, GA, LA, MS, NC, OK, SC, TX, TN)
○	Canada
○	Mexico
○	Other (Please specify the country):

6. Please rate your level of expertise in the field of Lean Manufacturing.

○	1 - Very Low
○	2 - Low
○	3 - Medium
○	4 - High
○	5 - Very High

7. How many years of *Lean manufacturing* related work experience do you have?

○	0 to 5 years
○	6 to 10 years
○	11 to 15 years
○	15 to 20 years
○	More than 20 years

8. Please indicate your level of commitment to serve as an expert on the Delphi panel and complete all three rounds of Delphi Study.

○	1 - Very Low
○	2 - Low
○	3 - Medium
○	4 - High
○	5 - Very High

9. The three rounds of Delphi questionnaires will be sent to panelists via the US postal service.
If you are interested in participating in this important research study, please provide the following contact information [*This information will be kept confidential and only used in conjunction with the research study*] :

Name (First Last):	
Mailing Address:	
City, State, ZIP	
Country:	
Email:	
Ph #:	

Clear Back Next

LEAN MANUFACTURING CERTIFICATION PRE-DELPHI SURVEY																			**Page 2 of 8**		

Please rate each of the three levels of examinations on the following:

IMPORTANCE. How important is it for the candidate to possess the competency?

NECESSARY FOR CERTIFICATION. Should the the competency be included in the certification examination?

<u>LEVELS OF CERTIFICATION:</u> [For more info click: <u>Description of the Three Levels of Lean Examination</u>]

1. Bronze (tactical level) – Candidates are expected to understand tactical implementation of lean principles and tools to drive improvements.

2. Silver (integrative level) – Candidates should know how to apply lean principles and tools at the value stream level, understand lean enterprise integration, and teach lean integration.

3. Gold (strategic level) – Candidates should know how to apply lean principles and tools to achieve significant business results, understand strategic enterprise transformation, teach lean strategy leadership, and have a strategic focus.

	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?	
	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
I. ENABLERS FOR LEAN **1.1.1 Business vision, mission, values, strategies & goals, including resource allocation (includes the following sub- topics)** 1.1.1.1 Business Vision 1.1.1.2 Business Mission 1.1.1.3 Business Purpose 1.1.1.4 Business Values, Philosophy, Ethics 1.1.1.5 Strategic Business Assessment 1.1.1.6 Strategy Development 1.1.1.7 Business Goals and Objectives 1.1.1.8 Core Competencies 1.1.1.9 Critical Success Factors 1.1.1.10 Resource Allocation	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1.1.2. Respect for Humanity and Social Responsibility (includes the following sub-topics) 1.1.2.1 Schools and Communities 1.1.2.2 Unions 1.1.2.3 Other Stakeholders	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
1.1.3. Long and Short-term Planning (includes the following sub-topics) 1.1.3.1 Hoshin Planning and Policy Deployment 1.1.3.2 Execution and Metrics 1.1.3.3 Project Management	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1.1.4. Principles of Lean leadership (includes the following sub-topics) 1.1.4.1 Go and See 1.1.4.2 Defining Value vs Non-value 1.1.4.3 Identifying Waste 1.1.4.4 Achieving Flow 1.1.4.5 Recognizing Normal vs. Abnormal 1.1.4.6 Respect for Humanity	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1.1.5. Lean corporate culture (includes the following sub-topics) 1.1.5.1 Value Stream Mapping 1.1.5.2 Kaizen Blitz Events 1.1.5.3 Continuous Improvement & Change 1.1.5.4 Communication of Business Values, Philosophy, Ethics 1.1.5.5 Change & knowledge management systems 1.1.5.6 Resource Standards & Measures for Business Results	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						

Clear Back Next

| | LEAN MANUFACTURING CERTIFICATION PRE-DELPHI SURVEY | Page 3 of 8 |

Please rate each of the three levels of examinations on the following:

IMPORTANCE. How important is it for the candidate to possess the competency?

NECESSARY FOR CERTIFICATION. Should the the competency be included in the certification examination?

LEVELS OF CERTIFICATION: [For more info click: Description of the Three Levels of Lean Examination]

1. Bronze (tactical level) – Candidates are expected to understand tactical implementation of lean principles and tools to drive improvements.

2. Silver (integrative level) – Candidates should know how to apply lean principles and tools at the value stream level, understand lean enterprise integration, and teach lean integration.

3. Gold (strategic level) – Candidates should know how to apply lean principles and tools to achieve significant business results, understand strategic enterprise transformation, teach lean strategy leadership, and have a strategic focus.

	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?	
	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
I. ENABLERS FOR LEAN **1.2.1. Principles of empowerment (includes the following sub-topics)** 1.2.1.1 Communication 1.2.1.2 Delegation 1.2.1.3 Recognition 1.2.1.4 Rewards 1.2.1.5 Employee Satisfaction & Morale 1.2.1.6 Employee & Labor Relations	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1.2.2. Employee training and development (includes the following sub-topics) 1.2.2.1 Instructional Goals 1.2.2.2 Skills Assessment 1.2.2.3 Continuous Learning Strategy 1.2.2.4 Cross-Training 1.2.2.5 Classroom and On-the-Job Training 1.2.2.6 Coaching & Mentoring	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
1.2.3. Teamwork (includes the following sub-topics) 1.2.3.1 Cross-Functional Team Selection & Leadership 1.2.3.2 Multi-Level Participation 1.2.3.3 Roles & Responsibilities 1.2.3.4 Decision-Making Types 1.2.3.5 Team Dynamics (Storming, norming, etc.)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1.2.4. Suggestion/Feedback/ Appraisal System (includes the following sub- topic) 1.2.4.1 Information Sharing	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1.2.5. Employee Turnover, Absenteeism and Compensation	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1.2.6. Ergonomic, clean and safe work environment, and results (includes the following sub-topics) 1.2.6.1 Environment 1.2.6.2 Ergonomics 1.2.6.3 Safety	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
	BRONZE (Tactical)							**SILVER (Integrative)**							**GOLD (Strategic)**						

I. ENABLERS FOR LEAN

List other areas that can be added under this domain. To view a complete list of existing areas under the current Lean BOK click here: **Lean Body of Knowledge**

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Clear   Back Next

| | LEAN MANUFACTURING CERTIFICATION PRE-DELPHI SURVEY | Page 4 of 8 |

Please rate each of the three levels of examinations on the following:

IMPORTANCE. How important is it for the candidate to possess the competency?

NECESSARY FOR CERTIFICATION. Should the the competency be included in the certification examination?

LEVELS OF CERTIFICATION: [For more info click: Description of the Three Levels of Lean Examination]

1. Bronze (tactical level) – Candidates are expected to understand tactical implementation of lean principles and tools to drive improvements.

2. Silver (integrative level) – Candidates should know how to apply lean principles and tools at the value stream level, understand lean enterprise integration, and teach lean integration.

3. Gold (strategic level) – Candidates should know how to apply lean principles and tools to achieve significant business results, understand strategic enterprise transformation, teach lean strategy leadership, and have a strategic focus.

	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?	
	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
II. LEAN CORE OPERATIONS **2.1.1. Operational Vision and Strategy (includes the following sub-topics)** 2.1.1.1 Operation Processes Vision, Mission, Strategy & Goals 2.1.1.2 Lean Principles in Strategy 2.1.1.3 Empowerment in Strategy 2.1.1.4 Operational Alignment with Organizational Vision, Mission, Strategy & Goals	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
2.2.1 Product Design and Development (includes the following sub-topics) 2.2.1.1 Quality Function Deployment 2.2.1.2 Concurrent Engineering 2.2.1.3 Variety Reduction 2.2.1.4 Engineering Changes 2.2.1.5 Design for Manufacture & Assembly 2.2.1.6 Design for Product Life Cycle (DFx) 2.2.1.7 Failure Mode & Effects Analysis (FMEA) 2.2.1.8 Life Cycle Engineering 2.2.1.9 Production Process Preparation (3P) 2.2.1.10 Knowledge Transfer Methods & Practices	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2.3.1. Suppliers (includes the following sub-topics) 2.3.1.1 Supplier Development Processes 2.3.1.2 Supplier Certification 2.3.1.3 Supplier Benchmarking 2.3.1.4 Supplier Satisfaction Measures 2.3.1.5 Corrective Action System	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2.3.2 Customers (includes the following sub-topics) 2.3.2.1 Customer Training & Development Processes 2.3.2.2 Customer Selection Focus 2.3.2.3 Demand Load Leveling 2.3.2.4 Corrective Action System	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2.3.3. Distribution & Transport Alliances (includes the following sub- topics) 2.3.3.1 Warehousing 2.3.3.2 Distribution Centers 2.3.3.3 Cross-Docks 2.3.3.4 Reverse Logistics 2.3.3.5 Remanufacturing/ Maintenance, Repair and Overhaul (MRO) 2.3.3.6 Just-in-Time Alliances 2.3.3.7 Supplier Managed Inventory Systems	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						

Clear Back Next

Please rate each of the three levels of examinations on the following:

IMPORTANCE. How important is it for the candidate to possess the competency?

NECESSARY FOR CERTIFICATION. Should the the competency be included in the certification examination?

LEVELS OF CERTIFICATION: [For more info click: Description of the Three Levels of Lean Examination]

1. Bronze (tactical level) – Candidates are expected to understand tactical implementation of lean principles and tools to drive improvements.

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3. Gold (strategic level) – Candidates should know how to apply lean principles and tools to achieve significant business results, understand strategic enterprise transformation, teach lean strategy leadership, and have a strategic focus.

	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?	
	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
II. LEAN CORE OPERATIONS **2.4.1. Systematic identification and elimination of waste (includes the following sub-topics)** 2.4.1.1 Waste Identification and elimination of waste 2.4.1.2 Value Stream Mapping 2.4.1.3 Value Analysis 2.4.1.4 5S Standards & Discipline 2.4.1.5 Visual Workplace 2.4.1.6 Kaizen Blitz Events 2.4.1.7 Mistake Proofing 2.4.1.8 Source Inspection 2.4.1.9 Continuous Improvement 2.4.1.10 Five Why's Problem Solving	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

2.4.2. Just-in-Time Operations (includes the following sub-topics)
2.4.2.1 Takt Time
2.4.2.2 Material Signals
2.4.2.3 Pull System
2.4.2.4 Continuous Flow
2.4.2.5 Just-in-Time (JIT)
2.4.2.6 Setup Reduction (SMED)
2.4.2.7 Total Productive Maintenance (TPM)
2.4.2.8 Load-Leveling (Heijunka)

2.4.3. Cellular & Continuous Flow (includes the following sub-topics)
2.4.3.1 Cellular Manufacturing
2.4.3.2 One Piece Flow
2.4.3.3 Standard Work
2.4.3.4 Multi-process Handling
2.4.3.5 Autonomation
2.4.3.6 Production Schedule
2.4.3.7 Bills of Materials
2.4.3.8 Routings
2.4.3.9 Flow Analysis Charts

2.4.4. Lean Tools for Continuous Improvement (includes the following sub-topics)
2.4.4.1 Plan-Do-Check-Act
2.4.4.2 Reliability & maintainability
2.4.4.3 Root Cause & Corrective Action
2.4.4.4 Flow Charting
2.4.4.5 Pareto
2.4.4.6 Cause & effect Diagrams
2.4.4.7 Check Sheets
2.4.4.8 Histograms
2.4.4.9 Scatter & Concentration Diagrams
2.4.4.10 Control Charts
2.4.4.11 Problem Solving Storyboards

4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						

II. LEAN CORE OPERATIONS

List other areas that can be added under this domain. To view a complete list of existing areas under the current Lean BOK click here: **Lean Body of Knowledge**

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LEAN MANUFACTURING CERTIFICATION PRE-DELPHI SURVEY	Page 6 of 8

Please rate each of the three levels of examinations on the following:

IMPORTANCE. How important is it for the candidate to possess the competency?

NECESSARY FOR CERTIFICATION. Should the the competency be included in the certification examination?

LEVELS OF CERTIFICATION: [For more info click: Description of the Three Levels of Lean Examination]

1. Bronze (tactical level) – Candidates are expected to understand tactical implementation of lean principles and tools to drive improvements.

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3. Gold (strategic level) – Candidates should know how to apply lean principles and tools to achieve significant business results, understand strategic enterprise transformation, teach lean strategy leadership, and have a strategic focus.

	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?	
	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
III. BUSINESS CORE OPERATIONS- SUPPORT FUNCTIONS 3.1.1 Administrative Vision & Strategy (includes the following sub-topics) 3.1.1.1 Application of Lean principles & techniques 3.1.1.2 Focus on value adds & waste identification & elimination 3.1.1.3 Commitment to Continuous Improvement 3.1.1.4 Business operations improvement metrics	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

| 3.1.2. Alignment & Systematic Business & Service Process Design (includes the following sub-topics)
3.1.2.1 Finance & Accounting: Measurement & control systems,etc
3.1.2.2 Human Resources: Alignment of selection, development, teamwork, performance feedback & discipline, compensation & rewards, etc.
3.1.2.3 Materials Management:Inventory Control,planning&scheduling,logistics, etc
3.1.2.4 Information Technology:Appropriate alignment with process changes, accessibility,etc
3.1.2.5 Sales&Marketing:Alignment of sales & operations planning&execution,etc
3.1.2.6 Quality Assurance: Regulation & certification, inspection rationale, etc
3.2.1.7 Process & Manufacturing Engineering: System for engineering changes, concurrent process, etc
3.2.1.8 Legal & Regulatory: Alignment with core lean thinking, etc | ☐ ☐ ☐ ☐ ☐ | ☐ ☐ | ☐ ☐ ☐ ☐ ☐ | ☐ ☐ | ☐ ☐ ☐ ☐ ☐ | ☐ ☐ |

4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						

III. BUSINESS CORE OPERATIONS-SUPPORT FUNCTIONS

List other areas that can be added under this domain.To view a complete list of existing areas under the current Lean BOK click here: **Lean Body of Knowledge**

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Clear Back Next

LEAN MANUFACTURING CERTIFICATION PRE-DELPHI SURVEY	Page 7 of 8

Please rate each of the three levels of examinations on the following:

IMPORTANCE. How important is it for the candidate to possess the competency?

NECESSARY FOR CERTIFICATION. Should the the competency be included in the certification examination?

LEVELS OF CERTIFICATION: [For more info click: Description of the Three Levels of Lean Examination]

1. **Bronze** (tactical level) – Candidates are expected to understand tactical implementation of lean principles and tools to drive improvements.

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3. **Gold** (strategic level) – Candidates should know how to apply lean principles and tools to achieve significant business results, understand strategic enterprise transformation, teach lean strategy leadership, and have a strategic focus.

	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?	
	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
IV. QUALITY, COST & DELIVERY MEASURES **4.1.1 Quality Results (includes the following sub-topics)** 4.1.1.1 Rework 4.1.1.2 Customer PPM Rejects 4.1.1.3 First Pass Yield 4.1.1.4 Scrap 4.1.1.5 Process Variation 4.1.1.6 Cost of Quality 4.1.1.7 Warranty Costs	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
4.2.1 Cost & Productivity Results (includes the following sub-topics) 4.2.1.1 Inventory Turns 4.2.1.2 Record Accuracy 4.2.1.3 Cycle Time, Takt Time and Throughput Time 4.2.1.4 Operational Equipment Effectiveness (OEE) 4.2.1.5 Labor Value-Add 4.2.1.6 Product Cost Reduction 4.2.1.7 Changeover 4.2.1.8 Resource Utilization 4.2.1.9 Energy Efficiency 4.2.1.10 Performance to Load Leveling	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
4.3.1 Delivery and Customer Service Measurement (includes the following sub-topics) 4.3.1.1 Line-Items Delivered On-Time to Customer Requirement 4.3.1.2 Complete Orders Delivered On-Time to Customer Requirements 4.3.1.4 Premium Freight 4.3.1.5 Mistakes in Shipment 4.3.1.6 Warranty Response, Service, etc.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
	BRONZE (Tactical)							**SILVER (Integrative)**							**GOLD (Strategic)**						

IV. QUALITY, COST & DELIVERY MEASURES

List other areas that can be added under this domain. To view a complete list of existing areas under the current Lean BOK click here: **Lean Body of Knowledge**

1.	
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Clear Back Next

LEAN MANUFACTURING CERTIFICATION PRE-DELPHI SURVEY	**Page 8 of 8**

Please rate each of the three levels of examinations on the following:

IMPORTANCE. How important is it for the candidate to possess the competency?

NECESSARY FOR CERTIFICATION. Should the the competency be included in the certification examination?

LEVELS OF CERTIFICATION: [For more info click: Description of the Three Levels of Lean Examination]

1. **Bronze** (tactical level) – Candidates are expected to understand tactical implementation of lean principles and tools to drive improvements.

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3. **Gold** (strategic level) – Candidates should know how to apply lean principles and tools to achieve significant business results, understand strategic enterprise transformation, teach lean strategy leadership, and have a strategic focus.

	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?	
	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
V. BUSINESS RESULTS **5.1.1 Customer Satisfaction Results (includes the following sub-topics)** 5.1.1.1 Market Share 5.1.1.2 Reorder Rate 5.1.1.3 Customer Survey Results 5.1.1.4 Customer Audit Results 5.1.1.5 Other Customer Feedback 5.1.1.6 Value/Improvement Analysis 5.1.1.7 Customer Retention 5.1.1.8 Customer Awards	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
5.2.1. Profitability Measurement (includes the following sub-topics) 5.2.1.1 Operating Income on Sales & Assets 5.2.1.2 Operating Income on Space 5.2.1.3 Fixed & Variable Costs 5.2.1.4 Cash Flow 5.2.1.5 Value Stream Profitability	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						

V. BUSINESS RESULTS	
List other areas that can be added under this domain. To view a complete list of existing areas under the current Lean BOK click here: **Lean Body of Knowledge**	

1.	
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Clear Back Submit

Thank you for participating in this survey. We appreciate your time and effort very much.

Appendix F

Round One of the Delphi Study

January 22, 2007

Subject: Lean Study - Round One Delphi

Dear :

Congratulations!! You are one among the 102 experts selected to serve on our SME/Shingo/AME Lean Certification Delphi panel. We sincerely thank you for your active participation in the Pre-Delphi round of our study and your commitment to serve as a Delphi panel member for the remainder of our study.

The focus of our study is to validate and refine the body of knowledge that forms the foundation of the Lean Manufacturing certification program, developed jointly by the Society of Manufacturing Engineers (SME), Shingo Prize for Excellence (Shingo), and Association for Manufacturing Excellence (AME). Your interest, expertise, and commitment to our study (along with that of the other Delphi panel members) will enable us to create and analyze a body of unique information, which will lead us to very valuable and valid results.

The three levels of the Lean Certification program are described below:

1. Bronze (tactical level) – Candidates should understand tactical implementation of lean principles and tools to drive improvements.

2. Silver (integrative level) – Candidates should know how to apply lean principles and tools at the value stream level, understand lean enterprise integration, and teach lean integration.

3. Gold (strategic level) – Candidates should know how to apply lean principles and tools to achieve significant business results, understand strategic enterprise transformation, teach lean strategy leadership, and have a strategic focus.

(For more information on the certification/Body of knowledge visit: http://sme.org/certification)

As a brief overview, our study will use a modified Delphi technique. The Delphi technique is a methodology used to seek consensus on a complex topic via a group of geographically dispersed experts that are recognized to participate on the Delphi panel. We will use this process to seek a majority and convergence of opinion for refining and validating the body of knowledge for the Bronze, Silver, and Gold SME/Shingo/AME Lean manufacturing certification examinations. The experts selected for our Delphi panel will record and share their opinions with each other via three rounds of a mailed Delphi survey questionnaire.

The process for our Delphi study is delineated as follows:

1. Pre-Delphi survey – identify experts for the study and identify a generalized opinion on the topic from a larger population. (Completed)

2. Round I – review the results of the Pre-Delphi survey and rate the importance of topics, with comments provided by the experts on the panel.

3. Round II – review the results of Round I and refine ratings of importance of topics, with additional comments provided by the experts on the panel.

4. Round III – review the refined results of Round II and seek final rating of topics, with concluding comments provided by the experts on the panel. All Delphi panelists will receive the final results of the study.

Please take a few minutes to complete this Round One questionnaire and send it back to me within two weeks of receiving it. For each competency area, provide your rating on a five point scale of importance: (4) extremely important, (3) very important, (2) moderately important, (1) slightly important, and (0) not important. Also rate if the competency area is necessary for the certification exam on a dichotomous scale: Yes – No. In other words consider, *how important is it for the candidate to possess the competency? Should the competency be included in the certification examination?*

When contemplating your response, consider the responses given by the participants from the Pre-Delphi round, shown as percent of concurrence and modal response to each competency area, and percent response to the question regarding the competency area being necessary for certification.

If your rating of a competency area is two or more categories away from the group's modal rating, please provide an explanation of your opinion for your associate panel member. Additional space is also provided to give your additional or general comments on the study at the end of the questionnaire.

Your responses will be kept anonymous. As mentioned earlier, all Delphi panelists will be included in each round of the study and will receive the final results of the study.

We are very much looking forward to working with you and the other experts on the panel. It will be exciting to see a group with such a high level of professionalism, expertise, and insight work together on this important research effort. Our results will prove to be a significant contribution to the discipline of Lean Manufacturing. Your interest and commitment to our study is greatly appreciated!

Sincerely,

Ms. Hiral Shah, CEI/CEM, CAPM   Dr. Tracy Tillman, CEI/CEM, CMfgE
Ph.D. Fellow   Chair, Ph.D. Dissertation Committee
Eastern Michigan University   Eastern Michigan University

Society of Manufacturing Engineers

22 January 2007

Dear Lean Advocate:

As the Society of Manufacturing Engineer's manager of certifications, and on behalf of the Association for Manufacturing Excellence and the Shingo Prize for Excellence in Manufacturing, I want to personally thank you for participating as a panel expert in the Delphi Study evaluating the Lean Certification Body of Knowledge. This study, conducted by Hiral Shah (under the direction of Tracy Tillman, PhD) at Eastern Michigan University will be one of the many mechanisms used to validate and continually improve the body of knowledge for the new multi–level Lean Certification program developed by SME, AME and the Shingo Prize. Ms. Shah is an active SME member, and we support the study that she is conducting.

Because of your particular expertise and insight related to Lean, your continued participation through the remaining rounds of this Delphi study is important and is very much appreciated.

We also welcome you to view the Lean Certification program in its entirety at www.sme.org/leancert.

Regards,

Jeannine Kunz
Manager, Certification

SME/AME/SHINGO LEAN CERTIFICATION ROLE DELINEATION STUDY
ROUND ONE DELPHI

Directions:

(1) Please look at the example below before completing the questionnaire. To complete the questionnaire, input your responses to each competency area by *check marking the box* which represents the rating you choose. **Please explain your choice** if it is two or more rating categories away from the modal (**in bold**) score. You may give any additional or general comments on the study in the space entitled "**Additional Comments**".

(2) Please email me back your completed questionnaire at: hiral.shah@emich.edu.

EXAMPLE:

Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination?	BRONZE (Tactical)					Necessary for Certification exam?		SILVER (Integrative)					Necessary for Certification exam?		GOLD (Strategic)					Necessary for Certification exam?	
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important		
I. ENABLERS FOR LEAN																					
1.1.1 Virtual Teams	4	3	*2*	1	0	Yes	*No*	4	*3*	2	1	0	*Yes*	No	*4*	3	2	1	0	*Yes*	No
	☐	☐	☐	☐	☑	☐	☑	☐	☑	☐	☐	☐	☑	☐	☑	☐	☐	☐	☐	☑	☐
	11%	19%	*36%*	26%	8%	46%	*54%*	20%	25%	25%	*30%*	0%	15%	*85%*	0%	7%	2%	1%	*90%*	2%	*98%*
	Comments: Knowledge of Virtual teams is not necessary for a bronze candidate							Comments: It is important for a candidate at Silver level to have working experience with virtual teams. Questions on this area should be on the exam.							Comments: It is extremely important for a Gold level to exemplify leadership in working as a virtual team. Questions on this area should be on the exam.						

Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination?	BRONZE (Tactical) Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important	Necessary for Certification exam?	SILVER (Integrative) Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important	Necessary for Certification exam?	GOLD (Strategic) Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important	Necessary for Certification exam?
I. ENABLERS FOR LEAN						
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	4 3 **2** 1 0 ☐ ☐ ☐ ☐ ☐	Yes **No** ☐ ☐	4 **3** 2 1 0 ☐ ☐ ☐ ☐ ☐	**Yes** No ☐ ☐	**4** 3 2 1 0 ☐ ☐ ☐ ☐ ☐	**Yes** No ☐ ☐
1.1.1.1 Business Vision	11% 19% **36%** 26% 8%	46% **54%**	20% **54%** 25% 1% 0%	**85%** 15%	**90%** 7% 2% 1% 0%	**98%** 2%
1.1.1.2 Business Mission	Comments:		Comments:		Comments:	
1.1.1.3 Business Purpose						
1.1.1.4 Business Values, Philosophy, Ethics						
1.1.1.5 Strategic Business Assessment						
1.1.1.6 Strategy Development						
1.1.1.7 Business Goals and Objectives						
1.1.1.8 Core Competencies						
1.1.1.9 Critical Success Factors						
1.1.1.10 Resource Allocation						
1.1.2. Respect for Humanity and Social Responsibility	4 3 2 **1** 0 ☐ ☐ ☐ ☐ ☐	Yes **No** ☐ ☐	4 3 **2** 1 0 ☐ ☐ ☐ ☐ ☐	Yes **No** ☐ ☐	**4** 3 2 1 0 ☐ ☐ ☐ ☐ ☐	**Yes** No ☐ ☐
1.1.2.1 Schools and Communities	15% 20% 22% **27%** 16%	34% **66%**	19% 27% **31%** 16% 7%	48% **52%**	**43%** 27% 18% 7% 5%	**70%** 30%
1.1.2.2 Unions	Comments:		Comments:		Comments:	
1.1.2.3 Other Stakeholders						
1.1.3. Long and Short-term Planning	4 3 **2** 1 0 ☐ ☐ ☐ ☐ ☐	**Yes** No ☐ ☐	4 **3** 2 1 0 ☐ ☐ ☐ ☐ ☐	**Yes** No ☐ ☐	**4** 3 2 1 0 ☐ ☐ ☐ ☐ ☐	**Yes** No ☐ ☐
1.1.3.1 Hoshin Planning & Policy Deployment	9% 21% **48%** 18% 4%	**63%** 37%	26% **55%** 18% 1% 0%	**95%** 5%	**70%** 21% 8% 1% 0%	**95%** 5%
1.1.3.2 Execution and Metrics	Comments:		Comments:		Comments:	
1.1.3.3 Project Management						

Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should thecompetency be included in the certification examination?	BRONZE (Tactical)			SILVER (Integrative)			GOLD (Strategic)		
	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important		Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important		Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important		Necessary for Certification exam?
I. ENABLERS FOR LEAN									
1.1.4. Principles of Lean leadership	4 ☐ 3 ☐ 2 ☐ 1 ☐ 0 ☐		*Yes* ☐ No ☐	4 ☐ 3 ☐ 2 ☐ 1 ☐ 0 ☐		*Yes* ☐ No ☐	4 ☐ 3 ☐ 2 ☐ 1 ☐ 0 ☐		*Yes* ☐ No ☐
1.1.4.1 Go and See	48% 30% 18% 3% 1%		**93%** 7%	58% 36% 6% 0% 0%		**98%** 2%	82% 9% 8% 1% 0%		**93%** 7%
1.1.4.2 Defining Value vs Non-value 1.1.4.3 Identifying Waste 1.1.4.4 Achieving Flow 1.1.4.5 Recognizing Normal vs Abnormal 1.1.4.6 Respect for Humanity	**Comments:**			**Comments:**			**Comments:**		
1.1.5. Lean corporate culture	4 ☐ **3** ☐ 2 ☐ 1 ☐ 0 ☐		*Yes* ☐ No ☐	4 ☐ 3 ☐ 2 ☐ 1 ☐ 0 ☐		*Yes* ☐ No ☐	4 ☐ 3 ☐ 2 ☐ 1 ☐ 0 ☐		*Yes* ☐ No ☐
1.1.5.1 Value Stream Mapping	31% **32%** 26% 10% 1%		**82%** 18%	58% 33% 9% 0% 0%		**98%** 2%	80% 14% 4% 2% 0%		**95%** 5%
1.1.5.2 Kaizen Blitz Events 1.1.5.3 Continuous Improvement & Change 1.1.5.4 Communication of Business Values, Philosophy, Ethics 1.1.5.5 Change & knowledge management systems 1.1.5.6 Resource Standards & Measures for Business Results	**Comments:**			**Comments:**			**Comments:**		
1.2.1. Principles of empowerment	4 ☐ 3 ☐ **2** ☐ 1 ☐ 0 ☐		*Yes* ☐ No ☐	4 ☐ **3** ☐ 2 ☐ 1 ☐ 0 ☐		*Yes* ☐ No ☐	4 ☐ 3 ☐ 2 ☐ 1 ☐ 0 ☐		*Yes* ☐ No ☐
1.2.1.1 Communication	15% 25% **37%** 19% 4%		**60%** 40%	33% **50%** 16% 1% 0%		**93%** 7%	74% 17% 8% 1% 0%		**92%** 8%
1.2.1.2 Delegation 1.2.1.3 Recognition 1.2.1.4 Rewards 1.2.1.5 Employee Satisfaction & Morale 1.2.1.6 Employee & Labor Relations	**Comments:**			**Comments:**			**Comments:**		

Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination? **I. ENABLERS FOR LEAN**	BRONZE (Tactical)					Necessary for Certification exam?		SILVER (Integrative)					Necessary for Certification exam?		GOLD (Strategic)					Necessary for Certification exam?	
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Yes	No	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Yes	No	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Yes	No
1.2.2. Employee training and development	4	3	*2*	1	0	*Yes*	No	4	*3*	2	1	0	*Yes*	No	*4*	3	2	1	0	*Yes*	No
1.2.2.1 Instructional Goals	16%	25%	*35%*	19%	5%	**54%**	46%	35%	*40%*	22%	2%	1%	**91%**	9%	58%	24%	16%	2%	0%	**89%**	11%
1.2.2.2 Skills Assessment 1.2.2.3 Continuous Learning Strategy 1.2.2.4 Cross-Training 1.2.2.5 Classroom and On-the-Job Training 1.2.2.6 Coaching & Mentoring	**Comments:**							**Comments:**							**Comments:**						
1.2.3. Teamwork	4	3	*2*	1	0	*Yes*	No	4	3	2	1	0	*Yes*	No	4	3	2	1	0	*Yes*	No
1.2.3.1 Cross-Functional Team Selection & Leadership	16%	25%	*35%*	19%	5%	**82%**	18%	*56%*	33%	9%	2%	0%	**97%**	3%	*67%*	17%	15%	1%	0%	**90%**	10%
1.2.3.2 Multi-Level Participation 1.2.3.3 Roles & Responsibilities 1.2.3.4 Decision-Making Types 1.2.3.5 Team Dynamics (Storming, norming, etc.)	**Comments:**							**Comments:**							**Comments:**						
1.2.4. Suggestion/Feedback/ Appraisal System	4	3	*2*	1	0	*Yes*	No	4	*3*	2	1	0	*Yes*	No	4	3	2	1	0	*Yes*	No
1.2.4.1 Information Sharing	15%	28%	*35%*	18%	5%	**52%**	48%	30%	*43%*	23%	4%	0%	**79%**	21%	*52%*	31%	14%	2%	1%	**80%**	20%
	Comments:							**Comments:**							**Comments:**						

Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination?	BRONZE (Tactical)					SILVER (Integrative)					GOLD (Strategic)				
	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important				Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important				Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important				Necessary for Certification exam?
I. ENABLERS FOR LEAN															
1.2.5. Employee Turnover, Absenteeism and Compensation	4 ☐	3 ☐	*2* ☐	1 ☐	0 ☐	Yes ☐ / *No* ☐	4 ☐	*3* ☐	2 ☐	1 0 ☐	Yes ☐ / *No* ☐	4 ☐	3 ☐	2 ☐	1 0 ☐	*Yes* ☐ / No ☐
	3%	12%	*36%*	31%	18%	23% / **77%**	10%	*36%*	30%	18% 6%	49% / **51%**	**42%**	24%	23%	7% 4%	**70%** / 30%
	Comments:						Comments:					Comments:				
1.2.6. Ergonomic, clean and safe work environment, and results	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐ / No ☐	*4* ☐	3 ☐	2 ☐	1 0 ☐	**Yes** ☐ / No ☐	4 ☐	3 ☐	2 ☐	1 0 ☐	*Yes* ☐ / No ☐
1.2.6.1 Environment	**43%**	30%	21%	6%	0%	**83%** / 27%	44%	35%	17%	3% 1%	**89%** / 11%	52%	22%	20%	4% 2%	**84%** / 16%
1.2.6.2 Ergonomics	Comments:						Comments:					Comments:				
1.2.6.3 Safety																
Additional Areas from Pre-Delphi																
Motivation Theory	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐ / No ☐	4 ☐	3 ☐	2 ☐	1 0 ☐	Yes ☐ / No ☐	4 ☐	3 ☐	2 ☐	1 0 ☐	*Yes* ☐ / No ☐
	Comments:						Comments:					Comments:				
Socio-technical Systems (An approach to design work that involves the interaction between people & technology at workplace)	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐ / No ☐	4 ☐	3 ☐	2 ☐	1 0 ☐	Yes ☐ / No ☐	4 ☐	3 ☐	2 ☐	1 0 ☐	Yes ☐ / No ☐
	Comments:						Comments:					Comments:				

Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination? **II. LEAN CORE OPERATIONS**	BRONZE (Tactical)					Necessary for Certification exam?		SILVER (Integrative)					Necessary for Certification exam?		GOLD (Strategic)					Necessary for Certification exam?	
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important		
2.1.1. Operational Vision and Strategy	4 ☐	3 ☐	*2* ☐	1 ☐	0 ☐	Yes ☐	*No* ☐	4 ☐	*3* ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐	No ☐	*4* ☐	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐	No ☐
2.1.1.1 Operation Processes Vision, Mission, Strategy & Goals	9%	16%	*39%*	27%	9%	46%	*54%*	20%	*48%*	28%	4%	0%	*81%*	19%	*75%*	19%	6%	0%	0%	*98%*	2%
2.1.1.2 Lean Principles in Strategy 2.1.1.3 Empowerment in Strategy 2.1.1.4 Operational Alignment with Organizational Vision, Mission, Strategy & Goals	**Comments:**							**Comments:**							**Comments:**						
2.2.1 Product Design and Development	4 ☐	3 ☐	*2* ☐	1 ☐	0 ☐	*Yes* ☐	No ☐	4 ☐	*3* ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐	No ☐
2.2.1.1 Quality Function Deployment	17%	21%	*37%*	20%	5%	*53%*	47%	36%	*43%*	21%	0%	0%	*91%*	9%	*57%*	26%	13%	3%	8%	*89%*	11%
2.2.1.2 Concurrent Engineering 2.2.1.3 Variety Reduction 2.2.1.4 Engineering Changes 2.2.1.5 Design for Manufacture & Assembly 2.2.1.6 Design for Product Life Cycle (DFx) 2.2.1.7 Failure Mode & Effects Analysis (FMEA) 2.2.1.8 Life Cycle Engineering 2.2.1.9 Production Process Preparation (3P) 2.2.1.10 Knowledge Transfer Methods & Practices	**Comments:**							**Comments:**							**Comments:**						

Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination? **II. LEAN CORE OPERATIONS**	BRONZE (Tactical)					Necessary for Certification exam?		SILVER (Integrative)					Necessary for Certification exam?		GOLD (Strategic)					Necessary for Certification exam?	
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important		
2.2.2. Product Market Service	4 ☐	3 ☐	**2** ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐
2.2.2.1 Customer Feedback & Market Needs Analysis 2.2.2.2 Customer Specs and Requirements 2.2.2.3 New market development & current market exploitation 2.2.2.4 E-commerce systems 2.2.2.5 Benchmarking	Comments:							Comments:							Comments:						
2.3.1. Suppliers	4 ☐	3 ☐	**2** ☐	1 ☐	0 ☐	Yes ☐	*No* ☐	4 ☐	*3* ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐	No ☐
2.3.1.1 Supplier Development Processes	12%	20%	**31%**	27%	10%	47%	**53%**	31%	**44%**	22%	2%	1%	**86%**	14%	62%	24%	13%	1%	0%	**90%**	10%
2.3.1.2 Supplier Certification 2.3.1.3 Supplier Benchmarking 2.3.1.4 Supplier Satisfaction Measures 2.3.1.5 Corrective Action System	Comments:							Comments:							Comments:						
2.3.2 Customers	4 ☐	3 ☐	2 ☐	*1* ☐	0 ☐	*Yes* ☐	No ☐	4 ☐	*3* ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐	No ☐	*4* ☐	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐	No ☐
2.3.2.1 Customer Training & Development Processes	14%	24%	26%	**30%**	6%	**51%**	49%	37%	**40%**	18%	4%	1%	**85%**	15%	57%	27%	15%	1%	0%	**87%**	13%
2.3.2.2 Customer Selection Focus 2.3.2.3 Demand Load Leveling 2.3.2.4 Corrective Action System	Comments:							Comments:							Comments:						

Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination? **II. LEAN CORE OPERATIONS**	BRONZE (Tactical)					Necessary for Certification exam?		SILVER (Integrative)					Necessary for Certification exam?		GOLD (Strategic)					Necessary for Certification exam?	
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important		
2.3.3. Distribution & Transport Alliances	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	*No* ☐	4 ☐	*3* ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐
2.3.3.1 Warehousing	12%	18%	**35%**	27%	8%	47%	**53%**	25%	**47%**	26%	2%	0%	**79%**	21%	43%	36%	19%	2%	0%	**83%**	17%
2.3.3.2 Distribution Centers	Comments:							Comments:							Comments:						
2.3.3.3 Cross-Docks																					
2.3.3.4 Reverse Logistics																					
2.3.3.5 Remanufacturing/ Maintenance, Repair and Overhaul (MRO)																					
2.3.3.6 Just-in-Time Alliances																					
2.3.3.7 Supplier Managed Inventory Systems																					
2.4.1. Systematic identification and elimination of waste	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐
2.4.1.1 Waste Identification and elimination of waste	**70%**	22%	1%	7%	0%	**95%**	5%	**72%**	21%	6%	1%	0%	**99%**	1%	**71%**	16%	9%	4%	0%	**86%**	14%
2.4.1.2 Value Stream Mapping	Comments:							Comments:							Comments:						
2.4.1.3 Value Analysis																					
2.4.1.4 5S Standards & Discipline																					
2.4.1.5 Visual Workplace																					
2.4.1.6 Kaizen Blitz Events																					
2.4.1.7 Mistake Proofing																					
2.4.1.8 Source Inspection																					
2.4.1.9 Continuous Improvement																					
2.4.1.10 Five Why's Problem Solving																					

Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination? **II. LEAN CORE OPERATIONS**	BRONZE (Tactical)			Necessary for Certification exam?		SILVER (Integrative)			Necessary for Certification exam?		GOLD (Strategic)			Necessary for Certification exam?	
	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important					Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important					Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important				
2.4.2. Just-in-Time Operations	4 ☐ 3 ☐ 2 ☐ 1 ☐ 0 ☐			Yes ☐	No ☐	4 ☐ 3 ☐ 2 ☐ 1 ☐ 0 ☐			Yes ☐	No ☐	4 ☐ 3 ☐ 2 ☐ 1 ☐ 0 ☐			Yes ☐	No ☐
2.4.2.1 Takt Time	**62%** 23% 14% 1% 0%			**94** %	6%	**70%** 23% 7% 0% 0%			**98** %	2%	**65%** 15% 14% 5% 1%			**86** %	14%
2.4.2.2 Material Signals 2.4.2.3 Pull System 2.4.2.4 Continuous Flow 2.4.2.5 Just-in-Time (JIT) 2.4.2.6 Setup Reduction (SMED) 2.4.2.7 Total Productive Maintenance (TPM) 2.4.2.8 Load-Leveling (Heijunka)	**Comments:**					**Comments:**					**Comments:**				
2.4.3. Cellular & Continuous Flow	4 ☐ 3 ☐ 2 ☐ 1 ☐ 0 ☐			Yes ☐	No ☐	4 ☐ 3 ☐ 2 ☐ 1 ☐ 0 ☐			Yes ☐	No ☐	4 ☐ 3 ☐ 2 ☐ 1 ☐ 0 ☐			Yes ☐	No ☐
2.4.3.1 Cellular Manufacturing	**55%** 28% 15% 2% 0%			**90** %	10%	**60%** 31% 9% 0% 0%			**97** %	3%	**61%** 17% 17% 5% 0%			**86** %	14%
2.4.3.2 One Piece Flow 2.4.3.3 Standard Work 2.4.3.4 Multi-process Handling 2.4.3.5 Autonomation 2.4.3.6 Production Schedule 2.4.3.7 Bills of Materials 2.4.3.8 Routings 2.4.3.9 Flow Analysis Charts	**Comments:**					**Comments:**					**Comments:**				

Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination? **II. LEAN CORE OPERATIONS**	BRONZE (Tactical)					SILVER (Integrative)					GOLD (Strategic)				
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?

	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
2.4.4. Lean Tools for Continuous Improvement	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2.4.4.1 Plan-Do-Check-Act	67%	18%	13%	2%	0%	**92**%	8%	67%	23%	9%	1%	0%	**93**%	7%	**65**%	15%	13%	6%	1%	**89**%	11%
2.4.4.2 Reliability & maintainability 2.4.4.3 Root Cause & Corrective Action 2.4.4.4 Flow Charting 2.4.4.5 Pareto 2.4.4.6 Cause & effect Diagrams 2.4.4.7 Check Sheets 2.4.4.8 Histograms 2.4.4.9 Scatter & Concentration Diagrams 2.4.4.10 Control Charts 2.4.4.11 Problem Solving Storyboards	Comments:							Comments:							Comments:						

Additional Areas from Pre-Delphi																					
Six Sigma/Problem Solving Techniques	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐
	Comments:							Comments:							Comments:						
Quantitative Decision Making Techniques	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐
	Comments:							Comments:							Comments:						

II. *Additional Areas from Pre-Delphi*	BRONZE (Tactical)		SILVER (Integrative)		GOLD (Strategic)	
	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?
Simulation Technique	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ No ☐
	Comments:		Comments:		Comments:	
Optimization Techniques	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ No ☐
	Comments:		Comments:		Comments:	
Facilities Design and Layout	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ No ☐
	Comments:		Comments:		Comments:	
III. BUSINESS CORE OPERATIONS-SUPPORT FUNCTIONS	BRONZE (Tactical)		SILVER (Integrative)		GOLD (Strategic)	
	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?
3.1.1 Administrative Vision & Strategy	4 3 **2** 1 0 ☐ ☐ ☐ ☐ ☐	**Yes** ☐ No ☐	4 **3** 2 1 0 ☐ ☐ ☐ ☐ ☐	**Yes** ☐ No ☐	**4** 3 2 1 0 ☐ ☐ ☐ ☐ ☐	**Yes** ☐ No ☐
3.1.1.1 Application of Lean principles & techniques	13% 24% **40%** 18% 5%	**53** % 47%	28% **46** % 21% 4% 1%	**85** % 15%	66% 25% 7% 2% 0%	**93** % 7%
3.1.1.2 Focus on value adds & waste identification & elimination 3.1.1.3 Commitment to Continuous Improvement 3.1.1.4 Business operations improvement metrics	Comments:		Comments:		Comments:	

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III. BUSINESS CORE OPERATIONS-SUPPORT FUNCTIONS	BRONZE (Tactical)		SILVER (Integrative)		GOLD (Strategic)	
	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?
3.1.2. Alignment & Systematic Business & Service Process Design	4 3 *2* 1 0 ☐☐☐☐☐	Yes *No* ☐	4 *3* 2 1 0 ☐☐☐☐☐	*Yes* No ☐	*4* 3 2 1 0 ☐☐☐☐☐	Yes No ☐ ☐
3.1.2.1 Finance & Accounting: Measurement & control systems,etc	6% 15% **37**% 27% 15%	33% **67%**	20% **45%** 31% 4% 0%	**73%** 27%	**67**% 25% 8% 0% 0%	*Yes* No ☐ ☐
3.1.2.2 Human Resources: Alignment of selection, development, teamwork, performance feedback & discipline, compensation & rewards, etc. 3.1.2.3 Materials Management:Inventory Control,planning&scheduling,logistics, etc 3.1.2.4 Information Technology:Appropriate alignment with process changes, accessibility,etc 3.1.2.5 Sales&Marketing:Alignment of sales&operations planning&execution,etc 3.1.2.6 Quality Assurance: Regulation & certification, inspection rationale, etc 3.2.1.7 Process & Manufacturing Engineering: System for engineering changes, concurrent 3.2.1.8 Legal & Regulatory: Alignment with core lean thinking, etc	Comments:		Comments:		Comments:	
Additional Areas from Pre-Delphi						
Supply Chain Logistics	4 3 2 1 0 ☐☐☐☐☐	Yes No ☐	4 3 2 1 0 ☐☐☐☐☐	Yes No ☐	4 3 2 1 0 ☐☐☐☐☐	Yes No ☐
	Comments:		Comments:		Comments:	
Lean Accounting	4 3 2 1 0 ☐☐☐☐☐	Yes No ☐ ☐	4 3 2 1 0 ☐☐☐☐☐	Yes No ☐ ☐	4 3 2 1 0 ☐☐☐☐☐	Yes No ☐
	Comments:		Comments:		Comments:	
Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	4 3 2 1 0 ☐☐☐☐☐	Yes No ☐ ☐	4 3 2 1 0 ☐☐☐☐☐	Yes No ☐ ☐	4 3 2 1 0 ☐☐☐☐☐	Yes No ☐
	Comments:		Comments:		Comments:	

Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination? **IV. QUALITY, COST & DELIVERY MEASURES**	BRONZE (Tactical)					Necessary for Certification exam?		SILVER (Integrative)					Necessary for Certification exam?		GOLD (Strategic)					Necessary for Certification exam?	
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important		
4.1.1 Quality Results	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐	No ☐
4.1.1.1 Rework	*43%*	27%	22%	8%	0%	*86* %	14%	*50%*	32%	17%	1%	0%	*93%*	7%	*57%*	25%	14%	4%	0%	*80* %	20%
4.1.1.2 Customer PPM Rejects	Comments:							Comments:							Comments:						
4.1.1.3 First Pass Yield																					
4.1.1.4 Scrap																					
4.1.1.5 Process Variation																					
4.1.1.6 Cost of Quality																					
4.1.1.7 Warranty Costs																					
4.2.1 Cost & Productivity Results	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐	No ☐
4.2.1.1 Inventory Turns	*34%*	30%	27%	9%	0%	*78* %	22%	*56%*	29%	14%	1%	0%	*97* %	3%	*63%*	22%	12%	3%	0%	*88* %	12%
4.2.1.2 Record Accuracy	Comments:							Comments:							Comments:						
4.2.1.3 Cycle Time, Takt Time and Throughput Time																					
4.2.1.4 Operational Equipment Effectiveness (OEE)																					
4.2.1.5 Labor Value-Add																					
4.2.1.6 Product Cost Reduction																					
4.2.1.7 Changeover																					
4.2.1.8 Resource Utilization																					
4.2.1.9 Energy Efficiency																					
4.2.1.10 Performance to Load Leveling																					

Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination? **IV. QUALITY, COST & DELIVERY MEASURES**	BRONZE (Tactical)					Necessary for Certification exam?		SILVER (Integrative)					Necessary for Certification exam?		GOLD (Strategic)					Necessary for Certification exam?	
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important		
4.3.1 Delivery and Customer Service Measurement	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐
4.3.1.1 Line-Items Delivered On-Time to Customer Requirement	25%	**27%**	23%	20%	5%	**64**%	36%	**39%**	37%	20%	4%	0%	**93**%	7%	**58%**	22%	16%	3%	1%	**89**%	11%
4.3.1.2 Complete Orders Delivered On-Time to Customer Requirements 4.3.1.4 Premium Freight 4.3.1.5 Mistakes in Shipment 4.3.1.6 Warranty Response, Service, etc. *Additional Areas from Pre-Delphi*	Comments:							Comments:							Comments:						
International Organization for Standardization (ISO) and Lean	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐
	Comments:							Comments:							Comments:						
Quality Management System (QMS)	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐
	Comments:							Comments:							Comments:						

Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination?	BRONZE (Tactical)			SILVER (Integrative)			GOLD (Strategic)		
	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important	Necessary for Certification exam?		Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important	Necessary for Certification exam?		Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important	Necessary for Certification exam?	
5.1.1 Customer Satisfaction Results	4 3 **2** 1 0 ☐☐☐☐☐	Yes ☐	**No** ☐	4 **3** 2 1 0 ☐☐☐☐☐	**Yes** ☐	No ☐	**4** 3 2 1 0 ☐☐☐☐☐	**Yes** ☐	No ☐
5.1.1.1 Market Share	8% 13% **35%** 29% 15%	28%	**72**%	16% **44%** 28% 12% 0%	**71%**	29%	66% 21% 10% 2% 0%	**93%**	7%
5.1.1.2 Reorder Rate 5.1.1.3 Customer Survey Results 5.1.1.4 Customer Audit Results 5.1.1.5 Other Customer Feedback 5.1.1.6 Value/Improvement Analysis 5.1.1.7 Customer Retention 5.1.1.8 Customer Awards	Comments:			Comments:			Comments:		
5.2.1. Profitability Measurement	4 3 2 *1* 0 ☐☐☐☐☐	Yes ☐	**No** ☐	4 **3** 2 1 0 ☐☐☐☐☐	**Yes** ☐	No ☐	**4** 3 2 1 0 ☐☐☐☐☐	**Yes** ☐	No ☐
5.2.1.1 Operating Income on Sales & Assets	9% 15% 27% **31**% 18%	31%	**69**%	23% **34%** 31% 11% 1%	**70%**	30%	69% 24% 5% 2% 0%	**93%**	7%
5.2.1.2 Operating Income on Space 5.2.1.3 Fixed & Variable Costs 5.2.1.4 Cash Flow 5.2.1.5 Value Stream Profitability	Comments:			Comments:			Comments:		
Additional Areas from Pre-Delphi									
Lean Business Metrics	4 3 2 1 0 ☐☐☐☐☐	Yes ☐	No ☐	4 3 2 1 0 ☐☐☐☐☐	Yes ☐	No ☐	4 3 2 1 0 ☐☐☐☐☐	Yes ☐	No ☐
	Comments:			Comments:			Comments:		
Total Supply Chain Cost	4 3 2 1 0 ☐☐☐☐☐	Yes ☐	No ☐	4 3 2 1 0 ☐☐☐☐☐	Yes ☐	No ☐	4 3 2 1 0 ☐☐☐☐☐	Yes ☐	No ☐
	Comments:			Comments:			Comments:		

Additional Comments if Any:

Thank you for your time and effort!

Subject: Delphi Round One Reminder #1

Dear Delphi Panel Expert:

We recently sent out the Round One Delphi questionnaire for our Lean Certification Role Delineation Study. We are looking forward to your participation as a Delphi panel expert in our study. If you have not yet had a chance to complete the Round One questionnaire, please try to do so and mail it back to me as soon as possible.

If you have not yet received the Round One questionnaire, please email me at: hiral.shah@emich.edu along with your complete address and I will send one to you immediately. *If you prefer filling in an electronic format, then please email me and I will send you an electronic copy of the survey.*

We hope to receive replies from all members of Delphi panel by mid-February. We can then analyze the information and report the Round One results back to you with the Round Two questionnaire in early March.

Your contribution and commitment to our study is most valued, and is essential to assuring validity in this research to create a standardized body of knowledge for the Lean manufacturing discipline. We very much appreciate your time, effort, and contribution.

Thank you in advance!

Sincerely,

Ms. Hiral Shah, Researcher   **Dr. Tracy Tillman, CMfgE, CEI/CEM**
Eastern Michigan University   Chair, Ph.D. Dissertation Committee
hiral.shah@emich.edu   Eastern Michigan University

Sub: Lean Delphi Round One Reminder   **Date: Feb 13, 2007**

Dear Lean Delphi Panel Expert,

We hope that you received the Round One questionnaire for our Delphi study a few weeks ago. Our goal is to delineate a standardized body of knowledge for the SME/AME/Shingo Lean manufacturing certification program. If you have not already done so, please take a few minutes to complete the Round One Delphi questionnaire that you received and return it to me as soon as possible.

If you need or prefer to use an electronic version of the survey, then please email me at hiral.shah@emich.edu and I will email one to you immediately.

Your participation in this study is very important. Your expertise and insight is very valuable and essential to helping us develop a valid research-based standardized body of knowledge for the field of Lean manufacturing. Our results will help to make the SME/AME/Shingo lean certification program more robust, and help to guide training, curriculum development, and future growth and development in other areas of lean manufacturing. We sincerely appreciate your time and effort involved in this project.

Respectfully,

Ms. Hiral Shah, Researcher   Dr. Tracy Tillman, Dissertation Chair
Eastern Michigan University   Eastern Michigan University

Date: March 2, 2007

Subject: Lean Delphi Panel Membership

Dear Lean Delphi Panel Expert,

Our records indicate that you had expressed interest in participating in our Delphi study research, the goal of which is to delineate a standardized body of knowledge for the field of Lean manufacturing that will be a framework for the SME/AME/Shingo Lean certifications. We have not yet received a response from you for Round One of our Delphi study. If you have already mailed in your Round One response, please let us know in a reply email to hiral.shah@emich.edu .

Because we have not yet received your response to Round One, we must know if you are still interested in serving on the Delphi panel. *Please reply to this email immediately to let me know if you still wish to participate in this study.* If you are still willing to participate, please send your completed Round One questionnaire to us right away. If not, please let us know and we will not contact you about the study any more.

Your expertise, if fully included in this research, will help to make it a better study. We very much appreciate your participation in the pre-Delphi round of our study and hope that you can continue to participate.

Sincerely,

Ms. Hiral Shah, Researcher   Dr. Tracy Tillman, Dissertation Chair
Eastern Michigan University   Eastern Michigan University

Date: March 19, 2007

Subject: Lean Delphi Study Membership Drop Out

Dear Pre-Delphi Study Participant,

Recently we had sent out an email asking your interest in continuing your membership on the Lean Delphi Panel. We have not received your Round One responses and have not heard back from you since then which makes us assume that you are not interested in pursuing as a Lean Delphi Panel Expert on our research project. Therefore, we are dropping you out from our list of panelist for this study.

You will not be contacted regarding this study anymore. We thank you for your participation in the pre-Delphi round of our study and regret that we could not utilize your responses in the subsequent rounds of the study.

We wish you all success in your Lean related endeavors.

Best regards,

Ms. Hiral Shah, Researcher   Dr. Tracy Tillman, Dissertation Chair
Eastern Michigan University   Eastern Michigan University

Appendix G

Round Two of the Delphi Study

March 19, 2007

Dear   :

Thank you for participating in Round One of our Delphi study, the goal of which is to validate and refine the body of knowledge that forms a framework for the Lean Manufacturing certification program, developed jointly by the Society of Manufacturing Engineers (SME), Shingo Prize for Excellence (Shingo), and Association for Manufacturing Excellence (AME).

With your enthusiasm and support, we were able to obtain a response rate of approximately 70% from Round One of the Delphi study. Your overwhelming interest in our research has helped us to collect important and valuable data, which will lead us to obtain good bottom-line qualitative and quantitative results. The prompt and thorough responses indicate the high level of professionalism of this panel and reflect the high degree of expertise and insight that panel members are able to bring to the study. Your responses and comments are shown in a separate document titled "Round One Results" for your reference. If you prefer to fill out an electronic copy of Round Two questionnaire, please email me at: hiral.shah@emich.edu

As a brief review, the three levels of the Lean Certification program are described below:

1. Bronze (tactical level) – Candidates should understand tactical implementation of lean principles and tools to drive improvements.

2. Silver (integrative level) – Candidates should know how to apply lean principles and tools at the value stream level, understand lean enterprise integration, and teach lean integration.

3. Gold (strategic level) – Candidates should know how to apply lean principles and tools to achieve significant business results, understand strategic enterprise transformation, teach lean strategy leadership, and have a strategic focus.

As you fill in your responses, please note that at the Silver and Gold level, it is required that a candidate has some mentoring and coaching experience in lean. Although candidates can apply directly for the Gold level, they are still required to complete the exam and portfolio for Bronze and Silver before they can take the Gold exam. (For more information on the certification/Body of knowledge visit: http://sme.org/certification)

A short overview of the process for our Delphi study is delineated as follows:

1. Pre-Delphi survey – identify experts for the study and identify a generalized opinion on the topic from a larger population. (Completed)

2. Round I – review the results of the Pre-Delphi survey and rate the importance of topics, with comments provided by the experts on the panel. (Completed)

3. Round II *(current round)* – review the results of Round I and refine ratings of importance of topics, with additional comments provided by the experts on the panel.

4. Round III – review the refined results of Round II and seek final rating of topics, with concluding comments provided by the experts on the panel. All Delphi panelists will receive the final results of the study.

Please take a few minutes to complete this Round Two questionnaire and send it back to me within two weeks of receiving it. For each competency area, provide your rating on a five point scale of importance: (4) extremely important, (3) very important, (2) moderately important, (1) slightly important, and (0) not important. Also rate if the competency area is necessary for the certification exam on a dichotomous scale: Yes – No. In other words consider, *how important is it for the candidate to possess the competency? Should the competency be included in the certification examination?*

When contemplating your response, consider the responses given by the participants from the Round One, shown as percent of concurrence and modal response to each competency area, and percent response to the question regarding the competency area being necessary for certification. In addition to providing comments on specific competency area, you may respond to any comments presented by other panel experts. Your responses will be kept anonymous.

If your rating of a competency area is two or more categories away from the group's modal rating, please provide an explanation of your opinion for your associate panel member. Additional space is also provided to give your additional or general comments on the study at the end of the questionnaire.

Together, we can define a body of knowledge in Lean Manufacturing and establish a merit for our discipline. We greatly appreciate your commitment and time involved in this important research study and look forward to your continued participation in our study.

Sincerely,

Ms. Hiral Shah, CEI/CEM, CAPM   Dr. Tracy Tillman, CEI/CEM, CMfgE
Ph.D. Fellow   Chair, Ph.D. Dissertation Committee
Eastern Michigan University   Eastern Michigan University

SME/AME/SHINGO LEAN CERTIFICATION ROLE DELINEATION STUDY
Results of Round One Delphi
1

Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination?	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	| Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	| Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	| Necessary for Certification exam?	

I. ENABLERS FOR LEAN

	BRONZE							SILVER							GOLD						
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	4	3	*2*	1	0	Yes	*No*	4	*3*	2	1	0	*Yes*	No	*4*	3	2	1	0	*Yes*	No
	☐	☐	▉	☐	☐	☐	▉	☐	▉	☐	☐	☐	▉	☐	▉	☐	☐	☐	☐	▉	☐
1.1.1.1 Business Vision	4%	9%	*58%*	26%	3%	23%	*77%*	10%	*73%*	17%	0%	0%	*93%*	7%	*93%*	7%	0%	0%	0%	*100%*	0%

1.1.1.2 Business Mission
1.1.1.3 Business Purpose
1.1.1.4 Business Values, Philosophy, Ethics
1.1.1.5 Strategic Business Assessment
1.1.1.6 Strategy Development
1.1.1.7 Business Goals and Objectives
1.1.1.8 Core Competencies
1.1.1.9 Critical Success Factors

Comments: - *Need a general idea about the business, esp. goals & core competencies - otherwise might not be focused on right issues.*
-Continuous improvement cannot be sustained unless tactical leaders understand and communicate business metrics (like IBT), and can design experiments to see how change impacts the metrics.
-An understanding of these ideas lifts the "pre-req" knowledge required to sit for the exam. This would add credibility to the certification. I feel that understanding manufacturing alone & the application of lean is too constraining.

Comments: - *One should have some business vision at this level.*
- Required at all levels to ensure that the lean work adds value to the overall corporation. Ie. Benefits not realized if leaning a non-bottleneck in the overall mfg. process.
- In order to be able to integrate lean you need to understand the vision, mission and purpose and how you got there.
- Must be able to tie the business to lean activities.
- Business vision is important, it helps you understand the companies goals which makes objectives meaningful. This should be on the exam.

Comments: - *It is very necessary to have business vision at the strategic level.*
- Very important to be a Gold.
- These are crucial building blocks at the strategic level.
- Must be able to understand and transfer the knowledge.
- Business vision is very important. This should be on the exam.
- To accomplish company goal lean leader must understand and participate in the strategic and development of the company goals.

SME/AME/SHINGO LEAN CERTIFICATION ROLE DELINEATION STUDY
Results of Round One Delphi

I. ENABLERS FOR LEAN	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important					Necessary for Certification exam?		Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important					Necessary for Certification exam?		Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important					Necessary for Certification exam?	
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	4	3	*2*	1	0	Yes	*No*	4	3	2	1	0	*Yes*	No	*4*	3	2	1	0	*Yes*	No
	☐	☐	■	☐	☐	☐	■	☐	■	☐	☐	☐	■	☐	■	☐	☐	☐	☐	■	☐
1.1.1.1 Business Vision	4%	9%	*58%*	26%	3%	23%	*77%*	10%	*73%*	17%	0%	0%	*93%*	7%	*93%*	7%	0%	0%	0%	*100%*	0%

1.1.1.2 Business Mission 1.1.1.3 Business Purpose 1.1.1.4 Business Values, Philosophy, Ethics 1.1.1.5 Strategic Business Assessment 1.1.1.6 Strategy Development 1.1.1.7 Business Goals and Objectives 1.1.1.8 Core Competencies 1.1.1.9 Critical Success Factors 1.1.1.10 Resource Allocation	*- Business vision is not necessary for a tactician.* *- Overview necessary. Certification necessary to assure understanding of context.* *- Some knowledge is needed in these areas to be able to understand the whole process and in particular vision, purpose, ethics, competencies and success factors.* *- At a tactical level I do not believe these high-level elements apply.* *- Tactical involvement is to execute the plan/projects.* *- Need to understand how it is tied to the business.* *- Business vision is somewhat important but not necessary for the examination*

SME/AME/SHINGO LEAN CERTIFICATION ROLE DELINEATION STUDY
Results of Round One Delphi

1.1.2. Respect for Humanity and Social Responsibility	4 ☐	3 ☐	2 ☐	*1* ■	0 ☐	Yes ☐	*No* ■	4 ☐	3 ☐	*2* ■	1 ☐	0 ☐	Yes ☐	*No* ■	*4* ■	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ■	No ☐
1.1.2.1 Schools and Communities	1%	4%	25%	*55%*	14%	14%	*86%*	3%	16%	*53%*	16%	3%	28%	*82%*	42%	48%	7%	3%	0%	*87%*	13%

| 1.1.2.2 Unions
1.1.2.3 Other Stakeholders | **Comments:** - *Also in 1.1.4.6. Duplicate ok?*
- *One should be starting out here.*
- *Higher if working in a union environment.*
- *Questions of importance S/B on exam.*
- *This is underestimated in practice. I prefer the term "people" over "humanity." Makes it more personal.*
- *Understanding and respecting other people is necessary for a successful lean program.*
- *At this level not a requirement. - Not necessary for the exam.* | **Comments:** - *While a very important concept and one I hold dearly, I do not believe it is important or even right for a lean certification.*
- *Minimal impact on results or approach.*
- *Highly important aspect, should be on exam.*
- *These entities are integral to lean success.*
- *Respect for people is required to succeed in any lean program.*
- *Need some awareness for running RIE - Not only respect, but understanding how human psychology and interaction affect team dynamics.*
- *Somewhat important, depends if you are dealing with unions, not necessary for exam.*
- *Cultural issues and Buy-in" are critical for success. The more the PMs understand the importance of company/organizational cultural issues, the more they will be able to mentally prepare for those battles.* | **Comments:** - *While a very important concept and one I hold dearly, I do not believe it is important or even right for a lean certification.*
- *Minimal impact on results or approach.*
- *While it may be an important business category, I don't think it highly critical for Lean certification.*
- *Important topic, but not sure how it can be effectively handled.*
- *Must be able to tie all types of stakeholders.*
- *This seems like a pre-condition to me. If you don't have this you will never approach this level.*
- *Very important, as a leader certain responsibilities are necessary. This should be on the exam.* |

SME/AME/SHINGO LEAN CERTIFICATION ROLE DELINEATION STUDY
Results of Round One Delphi

1.1.3. Long and Short-term Planning	4 3 **2** 1 0 ▢▢■▢▢	**Yes** ■	No ▢	4 **3** 2 1 0 ▢■▢▢▢	**Yes** ■	No ▢	**4** 3 2 1 0 ■▢▢▢▢	**Yes** ■	No ▢
1.1.3.1 Hoshin Planning & Policy Deployment	0% 22% 61% 17% 0%	**85%**	15%	17% 78% 5% 0% 0%	**100%**	0%	70% 21% 8% 1% 0%	**100%**	0%
1.1.3.2 Execution and Metrics 1.1.3.3 Project Management	**Comments:** - 3.2 & 3.3 belong in Bronze and Silver but I believe that 3.1 is a uniquely Gold topic based on the DEFINITION of the Gold level. - These candidates are more likely to participate than lead projects. - Being able to plan a project and identify key points is critical. - Only number two is really important at this level. - These are strategic issues. Context but test not required. - Everyone needs to know basic project management. - Execution and metrics are the important part for Bronze. - In order to know whether you are making progress you need to be able to measure it. - Ability to follow. - This is important to all levels. This should be included on the exam. - Disagree that this needs to be is as important at the lower level			**Comments:** - Book: 'Getting The Right Things Done' should be required reading for Silver and Gold. - People and systems perform based on how you measure them. - Involved in development. - Planning is key in being successful. This should be on the exam.			**Comments:** - It is important to project manager at this level. - I consider this more of an EHS issue. - It is crucial for success to be able to track performance accurately. - Leadership to create and meet. - Planning as a leader is what brings success. This should be on the exam.		

SME/AME/SHINGO LEAN CERTIFICATION ROLE DELINEATION STUDY
Results of Round One Delphi

Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination? **I. ENABLERS FOR LEAN**	BRONZE (Tactical)				SILVER (Integrative)				GOLD (Strategic)			
	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important			Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important			Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important			Necessary for Certification exam?
1.1.4. Principles of Lean leadership	**4** 3 2 1 0 ☐			*Yes* ☐ No ☐	**4** 3 2 1 0 ☐			*Yes* ☐ No ☐	**4** 3 2 1 0 ☐			*Yes* ☐ No ☐
1.1.4.1 Go and See	77% 20% 3% 0% 0%			*99%* 1%	91% 9% 0% 0% 0%			*100%* 0%	99% 0% 1% 0% 0%			*97%* 3%
1.1.4.2 Defining Value vs Non-value 1.1.4.3 Identifying Waste 1.1.4.4 Achieving Flow 1.1.4.5 Recognizing Normal vs Abnormal 1.1.4.6 Respect for Humanity	**Comments:** - *These topics are a must, but they are NOT principles.* - *Go an see very important.* - *It is important to understand lean thinking principles.* - *The first four sub-points are more lean practice than lean leadership. No blame; go to the source; respect for people (listen), etc would be a better list here.* - *Leadership is key at all levels to the success of lean programs. The difference between successful programs and failures is defined by leadership.* - *Need to identify waste and value vs non-value.* - *This is important to all levels. This should be included on the exam.*				**Comments:** - *These topics are a must, but they are NOT principles.* - *Identifying waste important.* - *It is important to understand lean thinking principles.* - *1.1.4.1_2_3_4 are required areas to be able to utilize.* - *This is important to all levels. This should be included on the exam.*				**Comments:** - *These topics are a must, but they are NOT principles.* - *Already tested 2x. No need to test again. Save question count for Gold level topics.* - *Go & see extremely important.* - *Must be able to master lean principles.* - *Should be sufficiently covered in previous exams.* - *Covered in Bronze.* - *Need to be an expert in all aspects except 1.1.4.5 (only if statistics are required)* - *This is important to all levels. This should be included on the exam.*			

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1.1.5. Lean corporate culture	4	3 ■	2	1	0	Yes ■	No	4 ■	3	2	1	0	Yes ■	No	4 ■	3	2	1	0	Yes ■	No
1.1.5.1 Value Stream Mapping	24%	57%	19%	0%	1%	93%	7%	83%	16%	1%	0%	0%	99%	1%	91%	6%	3%	0%	0%	100%	5%

| 1.1.5.2 Kaizen Blitz Events
1.1.5.3 Continuous Improvement & Change
1.1.5.4 Communication of Business Values, Philosophy, Ethics
1.1.5.5 Change & knowledge management systems
1.1.5.6 Resource Standards & Measures for Business Results | **Comments:** - *These topics are a must, but they are NOT principles nor is this culture.*
- Will be tested in Silver & Gold. These are more participants than levels.
- Tactical professionals might be only assistant in Kaizen events.
- It is necessary to understanding VSM principles.
- Focus exam content more on first 3 items.
- Again the first two subpoints suggest technique more than culture.
- 1.1.5.1 and .2 -Key elements of any lean program at any level.
- Value stream mapping is an important tool at tactical level & blitz events, but also more "integrative"
- Must understand VSM and Kaizen. - 1.1.5.1 (tool); 1.1.5.2 (technique); 1.1.5.4_5 (culture). Theses seem like a mix of tools, techniques & culture. I would not group these as culture. | **Comments:** - *Absolutely important.- 1.1.5.3 and 4*
- Communicates but doesn't set the strategy.
- Prepare and implement.
- This is important to all levels. This should be included on the exam. | **Comments:** - *Standard & measures are a must!*
- Extremely important.
- Focus exam content on last 3-4 items (1.1.5.3-1.1.5.6)
- Covered in Bronze.
- 1.1.5.4 and .5 and .6
- Prepare, implement and mentor.
- The area is too mixed: 1151 is a tool; 1152 is an event using tools; 1153-1154 are ideology; 1155 is tactical; 1156 deals with working metrics. Some should be tested, others not. |

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1.2.1. Principles of empowerment	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
1.2.1.1 Communication	4%	17%	58%	16%	4%	68%	32%	18%	73%	9%	0%	0%	99%	1%	94%	4%	2%	0%	0%	97%	3%

1.2.1.2 Delegation
1.2.1.3 Recognition
1.2.1.4 Rewards
1.2.1.5 Employee Satisfaction & Morale
1.2.1.6 Employee & Labor Relations

Comments: - Based on the definition of this level, this person can not make changes to the entire enterprise; this is BEYOND THE SCOPE.
- Will be tested in Silver & Gold. These are more participants than levels.
- These principles of empowerment are essential for any level-importance increases with level.
- Professional working at the tactical/operational level are closest to the workers that are influenced by lean thinking.
- Elements applicable to this level are not necessarily exam items, but should be experienced.
- Mid-management oriented. How does a team leader engage a team in suggestions and improvement every day? See 1.2.2
- At tactical level certification better for individual contributors. - This is more in the leadership side of the equation. It is my belief that Bronze should be more tactical.
- Not important at the tactical level.

- Not required on exam for tactical.
- Minor importance on rewards satisfaction.
- "Empowerment" --Don't like the word. This word is generally used & understood. I prefer "engaged"
- I think it's good to have an understanding at this level. Not necessary for the exam.

Comments: - People need to have a strong socio-technical background to make lean truly work.
- Employees suggestion systems should be required for both Silver and Gold.
- Communication etc are a key and necessary element of lean or any successful management program at all levels.
- Awareness of those concepts.
- This is relevant in strategizing. This should be on the exam

Comments: - Pick a change management strategy and be able to articulate it!!
- Understand and what is the ability to break down barriers.
- This should be on the exam.
- Most people at this level should already be aware and engaged concerning team work. Awareness training and testing shouldn't be needed. Concentrate on other areas for this group.

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Results of Round One Delphi

Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination? **I. ENABLERS FOR LEAN**	BRONZE (Tactical)					Necessary for Certification exam?		SILVER (Integrative)					Necessary for Certification exam?		GOLD (Strategic)					Necessary for Certification exam?	
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important		
1.2.2. Employee training and development	4 ☐	3 ☐	**2** ■	1 ☐	0 ☐	*Yes* ■	No ☐	4 ☐	**3** ■	2 ☐	1 ☐	0 ☐	*Yes* ■	No ☐	**4** ■	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ■	No ☐
1.2.2.1 Instructional Goals	4%	30%	*48%*	17%	0%	62%	38%	20%	*73%*	7%	0%	0%	99%	1%	*83%*	15%	1%	1%	0%	99%	1%

1.2.2.2 Skills Assessment 1.2.2.3 Continuous Learning Strategy 1.2.2.4 Cross-Training 1.2.2.5 Classroom and On-the-Job Training 1.2.2.6 Coaching & Mentoring	**Comments:** - *These are more participants than levels. Will test on Silver & Gold.* *- Training/experience might be on the cognitive engineering level.* *- Needed as these folks are the "do 'ers" making these things happen. - 1.2.2.5 & 1.2.2.6 - Strategy level -- not needed at Bronze level.* - *Knowing how to coach and train others is important at any lean leader level. Part of what's done in a kaizen event, etc. TWI?* - *At tactical level certification better for individual and team member contributors.* *- Not required at tactical level for exam* *- Skills and cross-training (multi-skilled operators)* *- This is essential for basic stability. You have nothing without this.* *- This is important and should be on the exam.*	**Comments:** - *Training/experience might be cognitive & macro-ergonomic level.* *- Success of any lean program and indeed any organization is based on the collective knowledge of the employees.* *- Need solid foundation of terms.* *- Extremely important if you are going to teach lean integration.* *- This is very important and should be on the exam.*	**Comments:** *These elements are vital but they are very tactical elements; that's not what Gold-Enterprise should be about.* *- Should be very strong in macro-ergonomic, and Human Performance Technology.* *- Must be able to establish as a function of sustaining the gains.* *- This is very important and should be on the exam.* *- Most people at this level should already be aware and engaged concerning team work. Awareness training and testing shouldn't be needed. Concentrate on other areas for this group.*

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1.2.3. Teamwork	4 3 **2** 1 0 ☐ ☐ ■ ☐ ☐	*Yes* ■	No ☐	**4** 3 2 1 0 ■ ☐ ☐ ☐ ☐	*Yes* ■	No ☐	**4** 3 2 1 0 ■ ☐ ☐ ☐ ☐	*Yes* ■	No ☐
1.2.3.1 Cross-Functional Team Selection & Leadership	9% 35% *50%* 7% 0%	*87%*	13%	*75%* 23% 2% 0% 0%	*100%*	0%	*83%* 16% 1% 0% 0%	*99%*	1%
1.2.3.2 Multi-Level Participation 1.2.3.3 Roles & Responsibilities 1.2.3.4 Decision-Making Types 1.2.3.5 Team Dynamics (Storming, norming, etc.)	**Comments:** - Basics you must do to implement. No once is an island anymore. - This group is more "in the battle" - very important to understand. - Some of this content is important at this level, but not critical overall for a tactical Body of Knowledge. - Essential for Bronze or they will have difficulty leaning project. - Not required at tactical level for exam - How to be a good team member. - Perhaps my view of "tactical" is too narrow, but I can see a "line" or single process as this. - Need to understand teamwork in order to know how to tactically implement anything in a workplace setting.			**Comments:** - Basic leadership skills and team dynamics.			**Comments:** - Can facilitate and run an effective team.		

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Results of Round One Delphi

1.2.4. Suggestion/Feedback/Appraisal System	4 3 **2** 1 0 ☐ ☐ ■ ☐ ☐	**Yes** ■	No ☐	4 **3** 2 1 0 ☐ ■ ☐ ☐ ☐	**Yes** ■	No ☐	**4** 3 2 1 0 ■ ☐ ☐ ☐ ☐	**Yes** ■	No ☐
1.2.4.1 Information Sharing	6% 23% 47% 21% 3%	**58%**	42%	15% 67% 16% 2% 0%	**91%**	9%	80% 18% 2% 0% 0%	**99%**	1%
	Comments: - This is an enterprise kind of change and not tactical execution. - These are more participants than levels. Will test on Silver & Gold. - The sooner this is mastered, the better. - What kind of information in what context? Implies answering, "What happened to my idea?" If workers simply implement ideas, they know what is happening. - Again, the goal of Bronze is the basic understanding. - Not required at tactical level for exam - Not critical at this level. - Information sharing concepts should not be required below the "integrative" level. - This is important and should be on the exam. Feedback is a key communication.			**Comments:** - One of the key principles of lean is that information is shared so that knowledge can be collectively increased. - Must be able to comprehend and analyze data. - Extremely important for success. - This is very important and should be on the exam.			**Comments:** - Required to create, analyze and interpret. - This is very important and should be on the exam.		

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Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination? **I. ENABLERS FOR LEAN**	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	_ Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	_ Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	_ Necessary for Certification exam?	
1.2.5. Employee Turnover, Absenteeism and Compensation	4	3	2	*1* ☑	0	Yes	*No* ☑	4	3	*2* ☑	1	0	Yes	*No* ☑	*4* ☑	3	2	1	0	*Yes* ☑	No
	1%	13%	32%	*48%*	6%	15%	*85%*	4%	43%	*49%*	4%	0%	36%	*64%*	*54%*	35%	9%	2%	0%	*84%*	16%

Comments (BRONZE): - *Not tactical, much broader, cultural & strategic topic.*
- Test limited to need for dependable people and compensation related to productivity.
- Absenteeism is a cost! Too often accepted as a % that is not controllable.
- People at this level impact the daily work & lives of personnel. They should be educated/tested on design principles to avoid this. -
This is important knowledge.
- Not at this level of deployment.
- Covers more than mere definition, I assume. Gets into morale, etc.
- Not important at the tactical level.
- Understanding of impact.
- This is slightly important and should be on the exam.
- Reduced importance at team member level

Comments (SILVER): - *Broader question.*
- People at this level impact the daily work & lives of personnel. They should be educated/tested on design principles to avoid this.
- The employee should be aware of what causes employee turn over.
- Should be required.
- Crosses into HR.
- Understanding of impact.
- Flow, teamwork, & Kaizen depend on high attendance and clear "what's in it for me?"
- This is important and should be on the exam

Comments (GOLD): - *Like any business topic, it fits with lean but does it really belong on a lean certificate?*
- Broadest questions.
- The need to understand these issues as strategic and know the limits of lean thinking and blend in socio-technical systems.
- This competency is one every manager should have, but not a lean tool.
- Useful at director level.
- Understanding why you keep employees and why they leave is a strategic aspect of lean management.
- Impact of turnover and rewards of success.
- Currently this is one of our most troublesome areas.
- This is important and should be on the exam

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1.2.6. Ergonomic, clean and safe work environment, and results	**4** 3 2 1 0 ☑☐☐☐☐	**Yes** ☑ No ☐	**4** 3 2 1 0 ☑☐☐☐☐	**Yes** ☑ No ☐	**4** 3 2 1 0 ☑☐☐☐☐	**Yes** ☑ No ☐
1.2.6.1 Environment	70% 28% 1% 1% 0%	**97%** 3%	77% 22% 1% 0% 0%	**99%** 1%	84% 13% 1% 2% 0%	**92%** 8%
1.2.6.2 Ergonomics 1.2.6.3 Safety	**Comments:** - *Need submicro level knowledge.* - *Cover in a different way at different levels.* - *Safety is important - primary - for everyone.* - *A safe and healthy work environment is basic to good management and therefore to a successful lean program poor safety will kill a lean program.* - *More so on safety and ergonomics.* - *Basics of 5S* - *I think this is generally underestimated & misunderstood.* - *It is important to be aware of Ergonomics and safety, this should be on the exam.*		**Comments:** - *Need micro/macro knowledge.* - *It is important to be aware of Ergonomics and safety, this should be on the exam.*		**Comments:** - *Amazing-there is no way that this should get a higher number for strategic than for tactical; Answers do not reflect an understanding of the levels.* - *Tested 2X.* - *Need macro level knowledge.* - *Understand requirements.* - *It is important to be aware of Ergonomics and safety, this should be on the exam.*	

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Additional Areas from Pre-Delphi	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
Motivation Theory	4	3	**2** ■	1	0	Yes	*No* ■	4	*3* ■	2	1	0	*Yes* ■	No	*4* ■	3	2	1	0	*Yes* ■	No
	7%	13%	*34%*	27%	4%	25%	**75%**	16%	*40%*	24%	8%	7%	*69%*	31%	47%	28%	13%	3%	9%	*80%*	20%

	BRONZE	SILVER	GOLD
	Comments: - *Makes for increased acceptance & respect becomes more important as level increases.* - *Motivation is a key leadership task.* - *Need individual motivation theory knowledge - Industrial/Organizational Psychology.* - *The basics should be understood.* - *Seems very tangential to a lean certification.* - *Necessary for understanding of team dynamics.* - *All kinds of motivation theory exist, from Maslow onward. Go back to 1.1.4, and build in how to motivate people for process improvement. Not a separate issue.* - *I don't know what this is.* - *It is key to be able to captivate a group, this should be on the exam* - *Need to define a structure for change that all can hang onto...see Evolution theory in my book and 12 step implementation process that allows all to know where they are...people need to know the process for change or they demotivate.*	**Comments:** - *Need social psychology motivation theory. "I/O and macro-ergonomics" should understand "high performance" company structures.* - *This knowledge is helpful to anyone teaching lean concepts.* - *Quite academic! Perhaps system designers could study this & boil it down to understandable & "do able" things on the floor. But otherwise at the workplace level it is not actionable.* - *It is key to be able to captivate a group, this should be on the exam.*	**Comments:** - *More important than thought.* - *Should know all that Bronze/Silver does as well. As inter-organizational and cross-cultural. Should also know organizational behavior, and corporate motives.* - *Leadership/facilitation- a must.* - *This knowledge is critical for success at this strategic level.* - *Understanding what motivates people.* - *Basic principles.* - *It is key to be able to captivate a group, this should be on the exam.*

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Socio-technical Systems	4	3	2	*1*	0	Yes	*No*	4	*3*	2	1	0	*Yes*	No	4	*3*	2	1	0	*Yes*	No
	☐	☐	☐	■	☐	☐	■	☐	■	☐	☐	☐	■	☐	☐	■	☐	☐	☐	■	☐
	5%	18%	28%	*34%*	15%	27%	*73%*	15%	*39%*	25%	15%	6%	*62%*	38%	31%	*35%*	25%	6%	3%	*73%*	28%

| (An approach to design work that involves the interaction between people & technology at workplace) | Comments: - *Someone's pet material- doesn't belong. Just because it's interesting and fits does not mean it should be jammed in.*
 - Ditto to Motivation Theory!
 - Knowledge of person/machine systems.
 - Seems very tangential to a lean certification.
 - Necessary for understanding of team dynamics.
 - Address this from a lean view in other categories. This old Brit system was good, but more of a forerunner.
 - Manufacturing system is interaction of people & equipment.
 - This is important and should be on the exam.
 - Must preach how important this subject is to making changes work..new vision must feel good and make sense so it gets embraced..must teach this. | Comments: - *Need to match technology level to skills attainable.*
 - Knowledge of people/machine(s) system(s).
 - Maybe - don't know enough about it.
 - Quite academic! Perhaps system designers could study this & boil it down to understandable & "do able" things on the floor. But otherwise at the workplace level it is not actionable.
 - This is important and should be on the exam. | Comments: - *Strategic knowledge of the changing work environment and how it effect corp. strategy and lean.*
 - Only a few questions on this since not all industry has this level of technology.
 - 3P succeeds with input of people to the technology used.
 - Maybe.
 - Basic principles.
 - This is important and should be on the exam. |

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Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination? **II. LEAN CORE OPERATIONS**	BRONZE (Tactical)				SILVER (Integrative)				GOLD (Strategic)			
	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important			Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important			Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important			Necessary for Certification exam?
2.1.1. Operational Vision and Strategy	4 3 **2** 1 0	☐ ☐ ■ ☐ ☐		Yes ☐ **No** ■	4 **3** 2 1 0	☐ ■ ☐ ☐ ☐		**Yes** ■ No ☐	**4** 3 2 1 0	■ ☐ ☐ ☐ ☐		**Yes** ■ No ☐
2.1.1.1 Operation Processes Vision, Mission, Strategy & Goals 2.1.1.2 Lean Principles in Strategy 2.1.1.3 Empowerment in Strategy 2.1.1.4 Operational Alignment with Organizational Vision, Mission, Strategy & Goals	1% 11% *63%* 23% 2%			25% **75%**	13% *71%* 16% 0% 0%			**95%** 5%	93% 7% 0% 0% 0%			**100%** 0%
	Comments: - *Should exhibit some mastery at this level.* - *Change will not be sustained unless vision-mission-strategy-and goals are aligned and the impact of tactical change is understand.* - *I feel that they should be aware of this at the functional group/dept. level for which they will likely support.* - *Crucial to senior management; others should know a little, even if not skill-building in the area.* -*Alignment important.* - *Need to have awareness of the vision, mission, strategy & goals.* - *Important to understand how lean fits into corporate goals and strategies.* - *There needs to be awareness maybe through a charter, but not necessary for exam.*			**Comments:** - *Integrative is not strategy.* - *Alignment important in proper integration.* - *Does activity have alignment with vision, mission,…* - *Do not see how you can integrate without alignment.* - *This is important at this level and should be on the exam.*				**Comments:** - *Important from a strategic point of view.* - *Expert in this area.* - *This is extremely important at this level and should be on the exam.*		

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2.2.1 Product Design and Development	4 ☐ 3 ☐ **2** ■ 1 ☐ 0 ☐	Yes ☐ **No** ■	4 ☐ *3* ■ 2 ☐ 1 ☐ 0 ☐	*Yes* ■ No ☐	*4* ■ 3 ☐ 2 ☐ 1 ☐ 0 ☐	*Yes* ■ No ☐
2.2.1.1 Quality Function Deployment	3% 15% *58%* 23% 1%	49% *51*%	13% *73%* 14% 0% 0%	*94%* 6%	75% 22% 3% 0% 0%	*96%* 4%

2.2.1.2 Concurrent Engineering

2.2.1.3 Variety Reduction

2.2.1.4 Engineering Changes

2.2.1.5 Design for Manufacture & Assembly

2.2.1.6 Design for Product Life Cycle (DFx)

2.2.1.7 Failure Mode & Effects Analysis (FMEA)

2.2.1.8 Life Cycle Engineering

2.2.1.9 Production Process Preparation (3P)

2.2.1.10 Knowledge Transfer Methods & Practices

Comments: - *Most of the work in the Bronze level is done in a portion of the company. This may not be the focus of the individual or even the company.*
- *Only test on reasons. 2.2.1.3 & 2.2.1.4 are important.*
- *One should understand the basics.*
- *Good knowledge to have but more for six sigma & engineers than pure lean. ..In fact in some ways it slows lean down.*
- *While some of this content is helpful, most of it is not directly used at a tactical level.*
- *Context familiarity only.*
- *Big mix of stuff, not all needing equal weight at all levels, but all need to know definitions, at least.*
- *Awareness.*
- *Most tactical Kaizens for the basic lean practitioner will not deal directly with product design issues or development processes; These are more advanced business processes.*
 - *I think it is somewhat important. These are manufacturing tools and a general understanding is important. Not necessary for the exam.*

Comments: - *Not necessary, but important.*
- *Key of this level.*
- *Lean is not lean without superior quality.*
- *User*
- *At this level it is important to have a working knowledge of these tools. It is important and should be on the exam.*

Comments: - *Gold test should cover much more design than Silver.*
- *(Depends on reporting structure) Only moderate if Gold is member of operations or quality. Extreme if reporting to CEO or VP of Division.*
- *Expert & mentor of concepts/techniques.*
- *At this level it is important to have a working knowledge of these tools. It is important and should be on the exam.*
- *Each subpoint is an excellent topic- all worthy of their own individual focus for learning and testing.*

SME/AME/SHINGO LEAN CERTIFICATION ROLE DELINEATION STUDY
Results of Round One Delphi

Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination?	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?	
II. LEAN CORE OPERATIONS	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
2.2.2. Product Market Service	☐	☐	☐	■	☐	☐	*No* ■	☐	■	☐	☐	☐	■	☐	■	☐	☐	☐	☐	■	☐
	1%	9%	33%	44%	13%	25%	75%	7%	47%	33%	13%	0%	60%	40%	52%	34%	14%	0%	0%	90%	10%

2.2.2.1 Customer Feedback & Market Needs Analysis
2.2.2.2 Customer Specs and Requirements
2.2.2.3 New market development & current market exploitation
2.2.2.4 E-commerce systems
2.2.2.5 Benchmarking

Comments: - .1 & .2 can be clearly connected to lean; .3 can fit but doesn't need to be there; .4 doesn't belong at all; and .5 is not needed anything that is included belongs to Gold.
- Assume customer focus will be tested elsewhere.
- Customer knowledge is increasingly essential at all levels.
- This area of knowledge might be targeted to a lean certification for non-manufacturing professionals.
- It is important to know the basics.
- Unless in the context of working with marketing.
- This content is important and necessary if a job is directly related to these activities. - VOC limited at this level.
- 2.2.2.2 - Very important!
- Another mix. All need to know how to deal with feedback from customers. But does a neophyte need to know formal benchmarking?

Comments: - VOC interaction & benchmarking get on radar.
- Customer feedback is the important component of this.
- Alignment with activities.
- Moderately important for silver. Not necessary for certification.

Comments: - Very important to seeing the value stream.
- Alignment with activities.
- Important for Gold level. Necessary for certification.

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Results of Round One Delphi

Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination? II. LEAN CORE OPERATIONS	BRONZE (Tactical)					Necessary for Certification exam?		SILVER (Integrative)					Necessary for Certification exam?		GOLD (Strategic)					Necessary for Certification exam?	
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important		
2.2.2. *Product Market Service*	4	3	2	**1** ■	0	Yes	**No** ■	4	**3** ■	2	1	0	**Yes** ■	No	**4** ■	3	2	1	0	**Yes** ■	No
2.2.2.1 Customer Feedback & Market Needs Analysis	1%	9%	33%	**44%**	13%	25%	**75%**	7%	**47%**	33%	13%	0%	**60%**	40%	52%	34%	14%	0%	0%	**90%**	10%
2.2.2.2 Customer Specs and Requirements 2.2.2.3 New market development & current market exploitation 2.2.2.4 E-commerce systems 2.2.2.5 Benchmarking	*-Only "yes" because of inclusion of customer specs & requirements.* *- Awareness only.* *- 2.2.2.1_2 -- Its basic that you meet customer demand. 2.2.2.3_5-- These I see as different depending on your business.2.2.2.4 -- N/A* *- Not important for bronze. Should not be necessary for certification.* *- This is not lean it's a specific discipline.*																				

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Results of Round One Delphi

2.3.1. Suppliers	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
	☐	☒	☐	☐	☐	☐	☒	☐	☒	☐	☐	☐	☒	☐	☒	☐	☐	☐	☐	☒	☐
2.3.1.1 Supplier Development Processes	11%	59%	27%	3%	0%	25%	75%	9%	73%	17%	1%	0%	96%	4%	80%	20%	0%	0%	0%	99%	1%

| 2.3.1.2 Supplier Certification
2.3.1.3 Supplier Benchmarking
2.3.1.4 Supplier Satisfaction Measures
2.3.1.5 Corrective Action System | **Comments:** - *Bronze is all about spot improvements, not value stream; why would this be here?*
- *These people will likely be working with a supply chain, albeit with four walls. The concepts still hold true, even if the supplier is in the next work area.*
- *One must be able to implement internally before coaching others.*
- *Context only important of supplier in tactical operation. Question S/B on exam.*
- *Very important to the company. 2.3.1.4 implies an initiative to be a preferred customer to suppliers, and everybody needs to know how they fit that.*
- *Supplier interactions are required.*
- *Impact on business objectives.*
- *Not important for bronze. Should not be necessary for certification.* | **Comments:** - *CAR & ISO integration competencies desired.*
- *Impact on business and assessment of suppliers.*
- *Moderately important for silver. Not necessary for certification.* | **Comments:** - *Critical to seeing the whole process.*
- *Development of supplier quality program.*
- *Important for Gold level. Necessary for certification.* |

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Results of Round One Delphi

2.3.2 Customers	4 3 2 *1* 0	Yes No	4 *3* 2 1 0	Yes No	*4* 3 2 1 0	Yes No
2.3.2.1 Customer Training & Development Processes	0% 12% 32% *50%* 6%	43% *57%*	13% *57%* 30% 0% 0%	*93*% 7%	*75*% 23% 2% 0% 0%	*100%* 0%

2.3.2.2 Customer Selection Focus

2.3.2.3 Demand Load Leveling

2.3.2.4 Corrective Action System

Comments: - C.A. system & how it works is essential to success!
- Understanding customer focus is important because we all have customers regardless of where we are in the food chain.
- Should be on exam for all levels.
- Particularly level loading, corrective action/8D's
- A person at this tactical level normally has little influence on these areas.
- Inappropriate for tactical.
- Important to higher leaders.
- "Level loading" is an important concept.
- Value to customer.
- 2.3.2.3 - Only at this level.
- Trying to implement lean without a stable production schedule is futile! Mura drives muda.
- Customer facing processes are outside the scope of most starting practitioners.

- Term means eliminating things the customer doesn't think is important- the two are inseparable.
- Not important for bronze. Should not be necessary for certification.
- Keeping Customers in the Lead requires focus and engagement from a Lean practitioner.

Comments: - The turbo step.
- A good corrective action process is a key element of a sound lean system.
- Determine value of activities to customer.
- Moderately important for silver. Not necessary for certification.

Comments: - Fundamental to VSM management.
- Establish customer relations, determine requirements.
- Important for Gold level. Necessary for certification.

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Results of Round One Delphi

Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination? **II. LEAN CORE OPERATIONS**	BRONZE (Tactical)					SILVER (Integrative)					GOLD (Strategic)				
	Extremely Important	Very Important	Moderately Important	Slightly Important / Not Important	Necessary for Certification exam?	Extremely Important	Very Important	Moderately Important	Slightly Important / Not Important	Necessary for Certification exam?	Extremely Important	Very Important	Moderately Important	Slightly Important / Not Important	Necessary for Certification exam?
2.3.3. Distribution & Transport Alliances	4	3	**2** ☑	1	0	Yes ☐ / **No** ☑	4	**3** ☑	2	1 0	**Yes** ☑ / No	**4** ☑	3	2	1 0	**Yes** ☑ / No
2.3.3.1 Warehousing	1%	0%	60%	36% 2%	25% **75%**	4%	70%	23%	3% 0%	**90**% 10%	62%	32%	4%	2% 0%	**99**% 1%

| 2.3.3.2 Distribution Centers

2.3.3.3 Cross-Docks

2.3.3.4 Reverse Logistics

2.3.3.5 Remanufacturing/ Maintenance, Repair and Overhaul (MRO)

2.3.3.6 Just-in-Time Alliances

2.3.3.7 Supplier Managed Inventory Systems | **Comments:** - *Distribution & transport belongs, but most of these line items are just current, widely-adopted tactics. If this is lean, then 95% of companies are done.*
- *2.3.3.3 Only*
- *Logistics management should be everyone's responsibility and awareness.*
- *Just as important as other processes that might require attention and "leaning out".*
- *Context necessary for tactical (Bronze) certification.*
- *Awareness.*
- *Too specialized.*
- *Any lean implementation beyond the production line needs to include supply side and inventory management.*
-*Not important for bronze. Should not be necessary for certification.* | **Comments:** - *Critical to growth management.*
- *The level where a candidate should demonstrate detailed knowledge.*
- *User*
- *Important for Silver level. Necessary for certification.* | **Comments:** - *Should be doing more strategically with developing pull system.*
- *A core competence to value stream management.*
- *At the gold level, assume that they know most of this.*
- *Leader, creator, developer & teacher. "Expert"*
- *Important for Gold level. Necessary for certification.* |

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Results of Round One Delphi

2.4.1. Systematic identification and elimination of waste	4 3 2 1 0 ☑☐☐☐☐	Yes No ☑ ☐	4 3 2 1 0 ☑☐☐☐☐	Yes No ☑ ☐	4 3 2 1 0 ☑☐☐☐☐	Yes No ☑ ☐
2.4.1.1 Waste Identification and elimination of waste	92% 6% 1% 1% 0%	99 % 1%	90% 9% 1% 0% 0%	100 % 0%	90% 10% 0% 0% 0%	94 % 6%

2.4.1.2 Value Stream Mapping

2.4.1.3 Value Analysis

2.4.1.4 5S Standards & Discipline

2.4.1.5 Visual Workplace

2.4.1.6 Kaizen Blitz Events

2.4.1.7 Mistake Proofing

2.4.1.8 Source Inspection

2.4.1.9 Continuous Improvement

2.4.1.10 Five Why's Problem Solving

Comments: - *Mistake proofing is more commonly stated as error proofing.*
- *Department level - sub micro.*
- *All the 2.4.x.x are the heart of lean application and important for each level to have appropriate understanding and mastery... at silver and gold SYSTEMS understanding is important for these categories.*
- *Identification and elimination of waste is what lean is about but these others are all key elements as well.*
- *Basic tools.*
- *Awareness "team member"*
- *All very basic. 2.4.1.6 (Kaizen Events)- hate these!- Tend to get out of context & create an "event" mentality rather than a way of life.*
- *Key stuff.*
- *This is important for bronze level and should be necessary for certification.*

Comments: - *Cost center and possibly divisional level. Micro/Macro.*
- *User*
- *This is important for silver level and should be necessary for certification.*

Comments: - *Don't see any need to test the basics 3X. Save question count for Gold issues.*
- *Cross company, service & multinational and strategic knowledge. Macro.*
- *2.4.1.6 - Ask why use Blitz? Tool to change culture - not needed in a problem solving culture.*
- *Important, but should be covered sufficiently in previous exams.*
- *At the gold level assume that all this is known and covered in prior exams.*
- *Assumes practitioner graduated from Bronze and Silver. If trying directly for Gold then rate as 4.*
- *Leader, creator, developer & teacher. "Expert"*
- *Tactical tools are covered intensively in the earlier stages of certification. The strategist should be well beyond the need to be tested on these fundamentals.*
- *Who is saying "NO" here? If the people in charge of strategic change management don't understand this, there is no hope of success at the enterprise level.*
- *This is important for gold level and should be necessary for certification.*

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Results of Round One Delphi

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Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination? **II. LEAN CORE OPERATIONS**	BRONZE (Tactical)			Necessary for Certification exam?	SILVER (Integrative)			Necessary for Certification exam?	GOLD (Strategic)			Necessary for Certification exam?
	Extremely Important / Very Important	Moderately Important / Slightly Important	Not Important		Extremely Important / Very Important	Moderately Important / Slightly Important	Not Important		Extremely Important / Very Important	Moderately Important / Slightly Important	Not Important	
2.4.2. Just-in-Time Operations	**4** 3 ☑ ☐	2 1 ☐ ☐	0 ☐	**Yes** No ☑ ☐	**4** 3 ☑ ☐	2 1 ☐ ☐	0 ☐	**Yes** No ☑ ☐	**4** 3 ☑ ☐	2 1 ☐ ☐	0 ☐	**Yes** No ☑ ☐
2.4.2.1 Takt Time	*85%* 15%	0% 0%	0%	*99* % 1%	*90%* 10%	0% 0%	0%	*100* % 0%	*85%* 13%	2% 0%	0%	*91* % 9%

2.4.2.2 Material Signals

2.4.2.3 Pull System

2.4.2.4 Continuous Flow

2.4.2.5 Just-in-Time (JIT)

2.4.2.6 Setup Reduction (SMED)

2.4.2.7 Total Productive Maintenance (TPM)

2.4.2.8 Load-Leveling (Heijunka)

Comments: - *Department level - sub micro.*
- *Need less 2.4.2.8 than Silver or Gold.*
- *All these are key parts of a lean system and therefore sound knowledge is required at all levels.*
- *Awareness "team member"*
- *Key stuff.*
- *This is important for bronze level and should be necessary for certification.*

Comments: - *Cost center and possibly divisional level. Micro/Macro.*
- *User*
- *This is important for silver level and should be necessary for certification.*

Comments: - *Don't see any need to test the basics 3X. Save question count for Gold issues.*
- *Cover previously.*
- *Assume that this is already known at this level.*
- *Assumes practitioner graduated from Bronze and Silver. If trying directly for Gold then rate as 4.*
- *Leader, creator, developer & teacher. "Expert"*
- *Tactical tools are covered intensively in the earlier stages of certification. The strategist should be well beyond the need to be tested on these fundamentals.*
- *This is important for gold level and should be necessary for certification.*
- *This topic, although important, is a lower level skill set that needs awareness at this level not operational effectiveness skills.*

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Results of Round One Delphi

2.4.3. Cellular & Continuous Flow	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
	■	☐	☐	☐	☐	■	☐	■	☐	☐	☐	☐	■	☐	■	☐	☐	☐	☐	■	☐
2.4.3.1 Cellular Manufacturing	80%	18%	2%	0%	0%	97 %	3%	90%	10%	0%	0%	0%	100%	0%	80%	15%	4%	1%	0%	93 %	7%

2.4.3.2 One Piece Flow
2.4.3.3 Standard Work
2.4.3.4 Multi-process Handling
2.4.3.5 Autonomation
2.4.3.6 Production Schedule
2.4.3.7 Bills of Materials
2.4.3.8 Routings
2.4.3.9 Flow Analysis Charts

Comments: - BOM's & routings should not be required.
- Department level - sub micro.
- These are all key elements of any lean system so sound knowledge at all levels required.
- I agree that these are essential competencies; however, care needs to be taken not to exclude those from process industries (paper, pharmaceutical, beverage, etc.) where these principles are applied with some creativity.
- Key stuff.
- This is important for bronze level and should be necessary for certification.

Comments: - Cost center and possibly divisional level. Micro/Macro.
- User
- This is important for silver level and should be necessary for certification.

Comments: - Don't see any need to test the basics 3X. Save question count for Gold issues.
- Cover previously.
- Covered at Bronze & Silver level.
- Put much more emphasis on strategy and human leadership at this level.
- Assumes practitioner graduated from Bronze and Silver. If trying directly for Gold then rate as 4.
- Leader, creator, developer & teacher.
- Tactical tools are covered intensively in the earlier stages of certification. The strategist should be well beyond the need to be tested on these fundamentals.
- This is important for gold level and should be necessary for certification.
- This topic, although important, is a lower level skill set that needs awareness at this level not operational effectiveness skills.

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Results of Round One Delphi

Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination? II. LEAN CORE OPERATIONS	BRONZE (Tactical)					SILVER (Integrative)					GOLD (Strategic)				
	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important				Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important				Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important				Necessary for Certification exam?
2.4.4. Lean Tools for Continuous Improvement	**4** ■	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ■ No ☐	**4** ■	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ■ No ☐	**4** ■	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ■ No ☐

	BRONZE						SILVER						GOLD					
2.4.4.1 Plan-Do-Check-Act 2.4.4.2 Reliability & maintainability 2.4.4.3 Root Cause & Corrective Action 2.4.4.4 Flow Charting 2.4.4.5 Pareto 2.4.4.6 Cause & effect Diagrams 2.4.4.7 Check Sheets 2.4.4.8 Histograms 2.4.4.9 Scatter & Concentration Diagrams 2.4.4.10 Control Charts 2.4.4.11 Problem Solving Storyboards	*83%*	15%	2%	0%	0%	*96*% 4%	*86%*	12%	2%	0%	0%	*99*% 1%	*83%*	13%	4%	0%	0%	*92*% 8%

Comments: - *Core*
- *These are basic components of lean. Candidate should understand these.*
- *More focus on 2.4.4.3 - 2.4.4.6 for Bronze.*
- *These are all key tools to implement lean and lean improvements so good knowledge is required at all levels.*
- *Awareness along with the ability to interpret*

Comments: - *Core*
- *More focus on PDCA in Silver & Gold.*
- *User creator.*

Comments: - *Don't see any need to test the basics 3X. Save question count for Gold issues.*
- *I view these more as traditional six sigma tools, not Lean tools...but they are useful tools.*
- *Core*
- *Focus on managing problem solving.*
- *Covered at Bronze & Silver level.*
- *Assume that this is already known at this level.*
- *Assumes practitioner graduated from Bronze and Silver. If trying directly for Gold then rate as 4.*
- *Awareness required.*
- *Leader, creator, expert, trainer.*
- *Tactical tools are covered intensively in the earlier stages of certification. The strategist should be well beyond the need to be tested on these fundamentals.*

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Results of Round One Delphi

Additional Areas from Pre-Delphi	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
Six Sigma/Problem Solving Techniques	4	3	**2**	1	0	Yes	**No**	4	**3**	2	1	0	Yes	No	**4**	3	2	1	0	**Yes**	No
	☐	☐	■	☐	☐	☐	■	☐	■	☐	☐	☐	■	☐	■	☐	☐	☐	☐	■	☐
	13%	21%	38%	22%	6%	42%	**58%**	29%	37%	23%	6%	5%	**74%**	26%	50%	34%	9%	1%	6%	**80%**	20%

| | **Comments:** - There are hundreds. The core tools are in 2.4.4. Could ask about DMAIC in PDCA section also.
- Logical quantitative techniques & management by fact is essential.
- Keep Lean certification & six sigma certification separate.
- Problem solving is important, but tools/concepts already covered.
- Trying to be too much like six sigma certification program?
- Six-Sigma overlaps with lean. Candidates should know definitions, but not how to do multi-variate statistical analysis, for instance.
- Methodology important to ensure benefits real and sustained.
- Good but not required.
- Awareness.
- At this level, adequately covered by 1.1.4.1, 2.4.4, 2.4.1.10, six sigma is very narrowly focused & has limited application according to Toyota.
- This is somewhat important but not necessary for certification.

- Add at all levels..teach the Motorola version not GE version..involve cross functional thinking to process lean. | **Comments:** - People need to understand that lean is only one tool in the the toolbox of OPEX. The true lean professional should know its limitations, and focus on speed. Six sigma will remind them of accuracy.
- Problem solving is important, but tools/concepts already covered.
- CI must attack variation waste.
- Need to know which tool to use.
- Methodology important to ensure benefits real and sustained.
- Green belt level.
- Its ok to use Statistical Process Control, but please don't call it "six sigma" & bring along all that baggage!
- Awareness is important.
- This is important and should be necessary for certification | **Comments:** - Six sigma has some overlap with lean, but it's focus is to reduce variation, not eliminate waste.
- Problem solving is important, but tools/concepts already covered.
- Critical to TQM.
- Need to know which tool to use.
- Methodology important to ensure benefits real and sustained.
- At a strategic level knowledge of 6 sigma very helpful.
- Black belt level.
- Awareness that six sigma is NOT a comprehensive approach is very important.
- This is important and should be necessary for certification |

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Quantitative Decision Making Techniques	4	3	2	1	0	Yes	*No*	4	*3*	2	1	0	*Yes*	No	*4*	3	2	1	0	*Yes*	No
	☐	☐	■	☐	☐	☐	■	☐	■	☐	☐	☐	■	☐	■	☐	☐	☐	☐	■	☐
	8%	22%	38%	22%	10%	38%	*62%*	23%	*47%*	23%	5%	2%	*72%*	28%	54%	30%	12%	3%	1%	*82%*	18%

Comments: *These are hundreds..Core tools handle 95% of problems according to Ishikawa. We probably should test so people realize PDCA+DMAIC are both equal scientific problem solving methods.* *- Ditto to Six Sigma above!* *- We live in a numbers world.* *- Critical to Team Kaizen facilitation.* *- PDCA, pareto, etc. are very important, but I think we risk bringing stray topics. The optimum amount of inventory is one (or none), for instance.* *- Methodology important to ensure benefits real and sustained.* *- As distinct from lean tools? Math applications?* *- Good but not required.* *- Ability to understand and interpret.* *- Underscore the cost time profile and baseline/entitlement/benchmark and balanced scorecard capitalization investment theories*	**Comments:** *- Methodology important to ensure benefits real and sustained* *- User.* *- Same as six sigma. Its all simple SPC that I learned back in 70's* *- But no one was giving out pretty color "belts" then.* *- This is important and should be necessary for certification*	**Comments:** *- Methodology important to ensure benefits real and sustained* *- Helpful but not necessary.* *- Advanced user.* *- This is important and should be necessary for certification*

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Results of Round One Delphi

II. *Additional Areas from Pre-Delphi*	BRONZE (Tactical)		SILVER (Integrative)		GOLD (Strategic)	
	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?
Simulation Technique	4 3 2 *1* 0 ☐ ☐ ☐ ■ ☐	Yes *No* ☐ ■	4 *3* 2 1 0 ☐ ■ ☐ ☐ ☐	*Yes* No ■ ☐	4 *3* 2 1 0 ☐ ■ ☐ ☐ ☐	*Yes* No ■ ☐
	3% 12% 29% 40% 16%	19% 81%	12% 35% 33% 16% 4%	52% 48%	20% 40% 23% 13% 4%	55% 45%
	Comments: - *Simulation Technique: Really should be a technique specialist as adjunct to lean specialist.* - *Simulation has limited application & value in total business sector.* - *Skills awareness training and primer to deployment requires simulation to improve learning comprehension.* - *Simulation has many applications. Simulating machine wear or layouts where there are heavy "monuments," etc. can be very useful. Questions should be relevant to lean process problem solving. Include mock up simulation, as with 3P.* - *Outside the scope of a tactical role.* - *This is somewhat important but not necessary for certification.* - *Add this bit only to show how these tools help sell the ideas the teams develop.*		**Comments:** - *This level of training is likely found in Bachelors and Masters/Doctorate degrees. So, requiring this would set the bar at a decent level as far as education requirements go.* - *Simulation beneficial but may be immature for many emerging technologies.* - How to do. - User. - *Its a tool- when you need it use it. Have not found much use of it for us.* - *Simulation application is limited & often too late.* - *This is important and should be necessary for certification*		**Comments:** - *Simulation can be very helpful when dealing with complex, multi-variable issues that would be focus of this level.* - *Simulation beneficial but may be immature for many emerging technologies.* - *Awareness of output, not how to.* - *A helpful tool but not necessary for a lean operation except in some circumstances.* - *Advanced user.* - *This is important and should be necessary for certification*	

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Optimization Techniques	4	3	2	*1*	0	Yes	*No*	4	3	*2*	1	0	*Yes*	No	4	*3*	2	1	0	*Yes*	No
	☐	☐	☐	■	☐	☐	■	☐	☐	■	☐	☐	■	☐	☐	■	☐	☐	☐	■	☐
	1%	19%	27%	*34%*	18%	24%	*76%*	16%	34%	*38%*	9%	3%	*55%*	45%	28%	*34%*	27%	6%	5%	*65%*	35%

Comments (col 1): -Ditto
- Isn't this what lean is all about?
- Fairly specialized skill set, all by itself. If added, should be focused.
- Depends on the context and application. Predictive maintenance has this element to it. Orient questions to applications, not to abstract techniques.
- Outside the scope of a tactical role.
- This is somewhat important but not necessary for certification
-CAREFUL…so much waste out there….. Need more breakthrough than optimization thinking but it does have a place.

Comments (col 2): - Important tools, but who has time to do this? Would lean people be able to "farm" this out? - Fairly specialized skill set, all by itself. If added,should be focused. - Important to ensure robustness is not compromised by lean project.
- How to do.
- User.
- Again a tool.
- This is important and should be necessary for certification

Comments (col 3): - Important to ensure robustness is not compromised by lean project.
- Awareness of when to use, not how to.
- A helpful set of tools but more of a supplementary set of skills rather than a necessary one for lean.
- Leader, creator, expert, trainer.
- It is counter to continuous improvement.
- This is important and should be necessary for certification

Facilities Design and Layout	4	3	*2*	1	0	Yes	*No*	4	*3*	2	1	0	*Yes*	No	*4*	3	2	1	0	*Yes*	No
	☐	☐	■	☐	☐	☐	■	☐	■	☐	☐	☐	■	☐	■	☐	☐	☐	☐	■	☐
	10%	24%	*39%*	22%	5%	48%	*52%*	32%	*38%*	22%	8%	0%	*80%*	20%	50%	23%	27%	0%	0%	*82%*	18%

Comments (col 1): - Ditto
- Assume this includes spaghetti diagrams.
- Probably covered enough in cellular & continuous flow section.
- Awareness.
- Pretty general statement-not sure what you mean by it. Certainly you must provide a basic supporting design to work in.
- This is somewhat important but not necessary for certification.
-The importance is high here…. A method to bring process and people together..very understated!!

Comments (col 2): - Very important tools and can make great impact.
- Big weakness in our company. Need it for flow & pull.
- Only as it pertains to enabling lean initiative.
- Awareness.
- This is important and should be necessary for certification

Comments (col 3): - Lean layout, flexible utility layouts, and so on, are a key part of lean.
- Some knowledge can be helpful but these are more in the line of skills you would use experts for.
- How it relates to lean principles.
- Setting up lean in a green field facility is much easier than a brown field.
- This is important and should be necessary for certification

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III. BUSINESS CORE OPERATIONS-SUPPORT FUNCTIONS	BRONZE (Tactical)		SILVER (Integrative)		GOLD (Strategic)	
	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?
3.1.1 Administrative Vision & Strategy	4 3 **2** 1 0	**Yes** No	4 **3** 2 1 0	**Yes** No	**4** 3 2 1 0	**Yes** No
3.1.1.1 Application of Lean principles & techniques	6% 18% *61%* 14% 1%	*76* % 25%	20% *71* % 9% 0% 0%	*99* % 1%	90% 10% 0% 0% 0%	*100* % 0%
3.1.1.2 Focus on value adds & waste identification & elimination 3.1.1.3 Commitment to Continuous Improvement 3.1.1.4 Business operations improvement metrics	**Comments:** -Low level concepts only. - Only slightly needed on Bronze. - CI is basic needed by all. - Too much in one category. Focus on "office lean" here. - A prerequisite. - Limited. - You can work in one area without this - Focus on key operation first.		**Comments:** *This topic area may be a part of specialist sub-certification for non-mfg professionals.* *- Important, but exam takes may have limited experience at this level.* *- Focus on uses of metrics, including dysfunctional uses.* *- Part of expectation.* *- If not then what does "integrative" mean.*		**Comments:** *- Obtaining & sustaining commitment is key here. How to "extend lean thinking."* *- At all levels you need to be able to understand each other and to measure or you will not be successful in lean.* *- Fundamental need.*	

III. BUSINESS CORE OPERATIONS-SUPPORT FUNCTIONS	BRONZE (Tactical)		SILVER (Integrative)		GOLD (Strategic)	
	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?
3.1.2. Alignment & Systematic Business & Service Process Design	4 3 **2** 1 0	Yes **No**	4 **3** 2 1 0	**Yes** No	**4** 3 2 1 0	**Yes** No
3.1.2.1 Finance & Accounting: Measurement & control systems,etc	1% 5% *60* % 30% 4%	15% *86*%	10% *66*% 24% 0% 0%	*87*% 13%	*85* % 15% 0% 0% 0%	*99*% 1%
3.1.2.2 Human Resources: Alignment of selection, development, teamwork, performance feedback & discipline, compensation & rewards, etc. 3.1.2.3 Materials Management: Inventory Control,planning&scheduling,logistics, etc 3.1.2.4 Information Technology: Appropriate alignment with process changes, accessibility,etc 3.1.2.5 Sales&Marketing:Alignment of sales&operations planning&execution,etc 3.1.2.6 Quality Assurance: Regulation & certification, inspection rationale, etc 3.2.1.7 Process & Manufacturing Engineering: System for engineering changes, concurrent 3.2.1.8 Legal & Regulatory: Alignment with core lean thinking, etc	**Comments:** *- Doesn't fit- dwells within specific systems, processes and organizational fit & alignment.* *- Supply Chain and Lean Accounting are equal to 3.1.2.1 and 3.1.2.3* *- These are areas where knowledge is needed in order to be able to understand effects. Higher the level the more important.* *- Some required, some not.* *- Awareness is max!* *- I think you should at least start to understand how this affect you.- it can kill you if you let it.* *- Outside of scope.* *- This is somewhat important but not necessary for certification*		**Comments:** *- Important, but exam takes may have limited experience at this level.* *- General knowledge.* *- This is important and should be necessary for certification*		**Comments:** *- Strong awareness and has voice in creation and update.* *- This is important and should be necessary for certification*	

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Additional Areas from Pre-Delphi	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
Supply Chain Logistics	4	3	**2**	1	0	Yes	**No**	4	3	2	1	0	**Yes**	No	**4**	3	2	1	0	**Yes**	No
	5%	3%	*52%*	32%	8%	24%	**76%**	10%	*54%*	28%	6%	2%	**80**%	20%	50%	39%	10%	1%	0%	**90**%	10%
	Comments: - I consider these a special subset that not every lean practitioner must master. - Suppliers and the supply chain are a key part of any lean operation. - Ultimately this must be in sync. - Outside of scope. - This is somewhat important but not necessary for certification							Comments: - This is important and should be necessary for certification. - Yes if in organization area of expertise							Comments: - Awareness. - This is important and should be necessary for certification						
Lean Accounting	4	3	2	*1*	0	Yes	**No**	4	**3**	2	1	0	**Yes**	No	**4**	3	2	1	0	**Yes**	No
	3%	4%	33%	*44%*	11%	25%	**75%**	10%	*40%*	36%	10%	4%	**62**%	38%	55%	32%	11%	1%	0%	**96**%	4%
	Comments: - I consider these a special subset that not every lean practitioner must master. - Fairly specialized skill set, all by itself. If added, should be focused. - Lean accounting is how to get a proper lean system to work when you run up against old style accountants. - This is somewhat important but not necessary for certification							Comments: - Implementers deal with it. - This is important and should be necessary for certification. - YES YES YES.... Get the accountants and bankers onboard...force them to be involved and the more others know the more this will be forced into place.							Comments: - Comprehension. - This is important and should be necessary for certification						

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Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
	☐	☐	■	☐	☐	☐	■	☐	☐	■	☐	☐	■	☐	■	☐	☐	☐	☐	■	☐
	8%	6%	42%	34%	10%	25%	75%	14%	36%	41%	3%	4%	65%	35%	43%	32%	19%	1%	5%	78%	22%

Comments: - How would stuff that is generally counter to lean ending on lean certification? - I thought this was already called out somewhere (e.g. 3.1.2.3) - I consider these a special subset that not every lean practitioner must master. - Need to know how to extract processes from MRP for Kanban. - Kill it. - Must be aware of traditional practices. - This is somewhat important but not necessary for certification	Comments: - Functioning of an MRP - In lean developing a pull system negates the need for MRP. MRP is a Push system. This should not be here!! - This is very important and should be necessary for certification - A must know about for most organizations..to avoid automating waste of info!	Comments: - How/if to link Lean+MRP - Knowledge is helpful, but not really part of lean. - This is important and should be necessary for certification

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Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination? **IV. QUALITY, COST & DELIVERY MEASURES**	BRONZE (Tactical) Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important	Necessary for Certification exam?	SILVER (Integrative) Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important	Necessary for Certification exam?	GOLD (Strategic) Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important	Necessary for Certification exam?
4.1.1 Quality Results	**4** ■ 3 □ 2 □ 1 □ 0 □	*Yes* ■ No □	**4** ■ 3 □ 2 □ 1 □ 0 □	*Yes* ■ No □	**4** ■ 3 □ 2 □ 1 □ 0 □	*Yes* ■ No □
4.1.1.1 Rework	73% 15% 10% 1% 1%	*91* % 9%	77% 16% 6% 0% 1%	**97**% 3%	78% 13% 7% 0% 2%	*93* % 7%
4.1.1.2 Customer PPM Rejects 4.1.1.3 First Pass Yield 4.1.1.4 Scrap 4.1.1.5 Process Variation 4.1.1.6 Cost of Quality 4.1.1.7 Warranty Costs	**Comments:** - *Again, I feel this is combining six sigma with Lean. So I believe the certification test should keep them separate.* - *I see that the emphasis should be more lean system design than quality at this level.* - *Good to know info but eliminating waste is the focus of lean.* - *More six sigma than lean.* - *Lots of questions here.* - *A good lean system is one where there is a good quality system.* - *Awareness.*		**Comments:** - *Ability to calculate.* - *Results matter! Now you get them matters more.*		**Comments:** - *Need to know for planning purposes.* - *Cover in previous exams.* - *Assume gold candidates already know this.* - *Ability to calculate for process and delivery* - *Too specific for this level.*	

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4.2.1 Cost & Productivity Results	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
	■	□	□	□	□	■	□	■	□	□	□	□	■	□	■	□	□	□	□	■	□
4.2.1.1 Inventory Turns	61%	29%	9%	1%	0%	**96**%	4%	90%	9%	1%	0%	0%	**99**%	1%	87%	10%	2%	1%	0%	**97**%	3%

4.2.1.2 Record Accuracy

4.2.1.3 Cycle Time, Takt Time and Throughput Time

4.2.1.4 Operational Equipment Effectiveness (OEE)

4.2.1.5 Labor Value-Add

4.2.1.6 Product Cost Reduction

4.2.1.7 Changeover

4.2.1.8 Resource Utilization

4.2.1.9 Energy Efficiency

4.2.1.10 Performance to Load Leveling

Comments: - *Test only on 4.2.1.1_1.2_1.3_1.7.*
- Emphasis on the metrics is too high for this level.
- These are all areas where some knowledge is needed for a good lean practitioner.
- Must be able to interpret results in $
- It is very hard to convince people that lean is NOT a thing you do, it is the WAY you DO everything.

Comments: -*Test only on 4.2.1.5*
- Must be able to interpret results in $

Comments: - *Great tactical metrics - how is this strategic? More confusion on what the levels mean.*
- Test only on 4.2.1.4_1.6_1.8_1.9_1.10.
- Cover in previous exams.
- Load these questions toward the Bronze Level.
- Must be able to interpret results in $

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Results of Round One Delphi

Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination? **IV. QUALITY, COST & DELIVERY MEASURES**	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?	
	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
4.3.1 Delivery and Customer Service Measurement		■				■		■					■		■					■	

4.3.1.1 Line-Items Delivered On-Time to Customer Requirement	BRONZE							SILVER							GOLD						
	15%	49%	27%	9%	0%	81%	19%	54%	40%	3%	3%	0%	96%	4%	80%	16%	1%	3%	0%	93%	7%

4.3.1.2 Complete Orders Delivered On-Time to Customer Requirements

4.3.1.4 Premium Freight

4.3.1.5 Mistakes in Shipment

4.3.1.6 Warranty Response, Service, etc.

Comments: - Emphasis on the metrics is too high for this level.
 - These are just metrics to measure improvements.
 - Customer service measures and corrective actions are very important to all levels, but a different level of question can also be asked.
 - At all levels is about better customer service.
 - Limited exposure and need for most projects.
- Not sure about these components. However this is what its all about-what does the customer get.
 - Moderately important but not required for certification.

Comments: - Impact on inventory one-piece flow.

Comments: - Cover in previous exams.
 - Need is critical to ensuring gains.

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Additional Areas from Pre-Delphi	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
	4	3	**2**	1	0	Yes	**No**	4	3	**2**	1	0	**Yes**	No	**4**	3	2	1	0	**Yes**	No
International Organization for Standardization (ISO) and Lean	5%	12%	38%	33%	12%	25%	75%	19%	28%	32%	15%	6%	65%	35%	43%	27%	18%	6%	6%	75%	25%

BRONZE — Comments: - *ISO is more often ANTI-Lean than supportive of it. It shouldn't be that way but it is.*
- *Ought to know the importance of ISO standard setting; little detail about a specific ISO standard.*
- *Maybe better certified separately.*
- *Integration awareness.*
- *This is important and should be necessary for certification*

SILVER — Comments: - *Only need to test on ISO purpose & benefits.*
- *Maybe better certified separately.*
- *Integration user.*
- *This is important and should be necessary for certification.*
- *Teach how to manage the issue of complicated systems of control for no return in performance how to get the balance of correct control comfort without the focus on improvement being lost..teach the parts that make this happen the most and stay away from those that don't .*

GOLD — Comments: - *Maybe better certified separately.*
- *At the higher levels an understanding helpful but not essential.*
- *Integration process owner.*
- *Executives must understand synergies & differences between the two systems.*
- *This is important and should be necessary for certification*

Quality Management System (AMES)	4	3	**2**	1	0	Yes	**No**	4	**3**	2	1	0	**Yes**	No	4	3	2	1	0	Yes	No
	7%	13%	46%	25%	9%	35%	65%	16%	37%	31%	8%	8%	71%	29%	45%	33%	14%	3%	5%	78%	22%

BRONZE — Comments: - *Not sure of the context of this, but the quality system is intertwined with lean in most places, and the QS creates the language for talking about problems and solutions. Some of QS is local and specific; enables people to look at reality on the scene; make decisions based on data, etc. Is much of this built in elsewhere? I'm getting concerned about length and redundancy -- especially redundancy that may be somewhat contradictory.*
- *This is repetitive of a previous one re quality but a quality system is part of every lean system.*
- *Integration awareness.*
- *Moderately important but not required for certification.*

SILVER — Comments: - *Integration user.*
- *Sounds like redundancy to me- Keep it simple. Create flow-Go & see- Solve problems. Don't make it hard!*
- *Less prevalent that ISO.*
- *This is important and should be necessary for certification.*
- *As above..old thinking...need process control not quality control!!!*

GOLD — Comments: - *Integration process owner.*
- *Awareness is important.*
- *This is important and should be necessary for certification.*

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Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination?	BRONZE (Tactical) Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important	Necessary for Certification exam?	SILVER (Integrative) Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important	Necessary for Certification exam?	GOLD (Strategic) Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important	Necessary for Certification exam?
5.1.1 Customer Satisfaction Results	4 3 **2** 1 0 [☑ at 2]	Yes / **No** [☑No]	4 **3** 2 1 0 [☑ at 3]	**Yes** [☑Yes] / No	**4** 3 2 1 0 [☑ at 4]	**Yes** [☑Yes] / No
5.1.1.1 Market Share	0% 6% 61% 30% 3%	13% **87%**	6% 65% 29% 0% 0%	**84%** 16%	81% 19% 0% 0% 0%	**100%** 0%
5.1.1.2 Reorder Rate 5.1.1.3 Customer Survey Results 5.1.1.4 Customer Audit Results 5.1.1.5 Other Customer Feedback 5.1.1.6 Value/Improvement Analysis 5.1.1.7 Customer Retention 5.1.1.8 Customer Awards	**Comments:** - *Getting repetitious, but customer feedback and correction is top priority. Will this fold in elsewhere?* - *Not at all important at tactical level.* - *General concepts only.* - *Didn't we already cover this. Clearly you need customer measures - not sure about each of these.*		**Comments:** - *This is important at an enterprise level.* - *This is only required at the higher levels.* - *Audit and customer feedback to compliment value analysis.*		**Comments:** - *Need to lead.*	
5.2.1. Profitability Measurement	4 3 2 *1* 0 [☑ at 1]	Yes / **No** [☑No]	4 *3* 2 1 0 [☑ at 3]	**Yes** [☑Yes] / No	*4* 3 2 1 0 [☑ at 4]	**Yes** [☑Yes] / No
5.2.1.1 Operating Income on Sales & Assets	2% 4% 32% 52% 10%	10% **90%**	9% 55% 32% 4% 0%	**83%** 17%	89% 9% 1% 1% 0%	**98%** 2%
5.2.1.2 Operating Income on Space 5.2.1.3 Fixed & Variable Costs 5.2.1.4 Cash Flow 5.2.1.5 Value Stream Profitability	**Comments:** - *Mastery here at levels is essential!* - *Focus on 5.2.1.4* - *Need to understand the impact of the application of lean on profitability.* - *This is a repeat of lean accounting same reasons apply.* - *Awareness & knowledge important for good decision-making.* - *No value.* - *Probably not working at the level where your progress will snow here.*		**Comments:** - *This is important at an enterprise level.* - *Important, but focus on other subject matter for exam.* - *Should be better covered in above lean metrics.* - *Somebody else's concern.* - *Awareness of impact.* - *It better start snowing here.*		**Comments:** - *Somebody else's concern.* - *Ability to calculate.* - *This should be a skill set this group already has.*	

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Additional Areas from Pre-Delphi	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
Lean Business Metrics	4	3	**2**	1	0	Yes	**No**	4	**3**	2	1	0	**Yes**	No	**4**	3	2	1	0	**Yes**	No
	☐	☐	■	☐	☐	☐	■	☐	■	☐	☐	☐	■	☐	■	☐	☐	☐	☐	■	☐
	3%	21%	44%	17%	15%	46%	54%	22%	51%	17%	3%	7%	85%	15%	71%	23%	0%	2%	4%	91%	9%

BRONZE Comments: - Didn't we already cover business metrics? This doesn't make sense.
- Should already be included in previous sections (e.g. 5.2.1)
- Fold this into lean accounting and lean performance measurements. Very important, and too scattered.
- This is a repeat of a previous one re business metrics
- Need to be able to incorporate.
- No such thing-these are only the same business results you ever used & wanted. What does Toyota use?
- This is important and should be necessary for certification.
- BIG!!!

SILVER Comments: - Redundant
- Overview only.
- For future leaders.
- Part of team to develop.
- This is important and should be necessary for certification

GOLD Comments: - Redundant
- Yes!!
- Process owner.
- Executives must select the metrics that will drive lean behavior.
- This is important and should be necessary for certification

Additional Areas from Pre-Delphi	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
Total Supply Chain Cost	4	3	2	**1**	0	Yes	**No**	4	**3**	2	1	0	**Yes**	No	**4**	3	2	1	0	**Yes**	No
	☐	☐	☐	■	☐	☐	■	☐	■	☐	☐	☐	■	☐	■	☐	☐	☐	☐	■	☐
	2%	8%	36%	38%	16%	23%	77%	12%	47%	35%	5%	1%	70%	30%	51%	39%	8%	1%	1%	88%	12%

BRONZE Comments: - Line item is lean accounting, may be, let now own topic.
- Should already be included in previous sections (e.g. 5.2.1)
- Although important from a "big picture" perspective, shouldn't these issues be more important in a SCM cert?
- Fold this into both "lean accounting" and Suppliers 2.3.1 Too little emphasis on suppliers. For advanced companies the big payoff from lean comes from suppliers and from the design process.
- This is a repeat of the supply chain one.
- Not required.
- Moderately important but not required for certification.

SILVER Comments: - Relative to likely level to participation in organization.
- Context only.
- Limited exposure.
- This is important and should be necessary for certification.
- Very low level of knowledge of the costs here…. Make part of decision process.

GOLD Comments: - Once again, trying to be "too much" in a single cert.?
- Awareness of impact.
- Executives considering offshore outsourcing must be equipped to make a balanced decision.
- This is important and should be necessary for certification

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Additional Comments if Any:

- There seems to be clear gap in understanding in the levels. Either the levels mean more or means different. Option 1: Silver should know MORE than Bronze and Gold should know more than silver. This seems to be the consensus, but I disagree based on how it is written. Option 2: Bronze is tactic stuff, Silver is integrative value stream stuff and Gold is strategic stuff. This means there should be things I must know in Bronze but not for Gold because the item is tactical & not strategic. Based on the observation that regardless of topic, Gold always had higher importance scores, this is not how it's being done. If option 1 is it, which is fine, the definitions of the levels MUST change.

- Basic Lean elements should be known by all but not tested 3 times. Save question count at Gold level for broader topics. At Silver & Gold levels we need to test consumption VSM + Provision VSM = Entire VSM (See Lean Solutions).

   - Having tried to master all the quantitative techniques available to support lean including simulation, optimization, RSM, non-linear Programming, etc. I think analysis to that level of sophistication should be left to subject matter experts. The lean practitioner needs to know these techniques exist and enough to know when to call in an expert though. Lean accounting, MRP and Supply-Chain expertise falls into that same category in my opinion. When one person has all the skills they are on overload! Spreading them around a team is good strategy!

   - The more you know, the more you can contribute! The bronze level should be exposed to everything that the silver and gold are using/need. Some is true of other levels in reflection to their complements. Tactical works inside the integration and strategic spheres.

   - Sorry it took so long. Got lost in my case between jobs.

   - As with all of the certification levels, the breadth and depth of knowledge should become more so. This should (might) include not only the topic of importance (by using the 5-point scale to rate the same) but also we could use the same 5-point scale to develop questions that have corresponding degrees of difficulty and knowledge. For example, for item 4.3.1, not only is it extremely important (a number rank of 4) for a Gold certificate holder's body of knowledge to know this information on customer service, but the degree of difficulty and depth of knowledge (with integrative skills) should be at a level of 4 too. This means that each certification level can get tested on the same topic but at different intellectual levels. In other words, I believe that all of these topic areas are important for each level of certification. I think, however, that the level of knowledge needed, and the relation to operational, tactical, or strategic strategy should be evaluated according to that level.

   - Bronze exam had too many "fuzzy (vague)" questions for a tactical level exam. I believe that Pascal Dennis's new book - 'Getting the Right Things Done' should be required reading for Silver & Gold levels. Gold portfolio should require at least one A3 project management document (with >= 3 months follow up data).

   - Some of the topics seemed like they were stretching beyond the boundaries of a single "lean certification", and trying to be too much.. trying to be "everything for everyone..".

contd..

SME/AME/SHINGO LEAN CERTIFICATION ROLE DELINEATION STUDY
Results of Round One Delphi

- IN THE ITEM II, AT "FACILITIES DESIGN," THE SOFTWARE SUDDENLY WOULD NOT STAY WITHIN THE COMMENTS WINDOW. YOU HAVE TO CLICK ON IT TO READ IT.   The mix of subtopics under several headings obviously complicates both completing a survey and interpreting it. The framework needs some reorganizing to sort out the stray stuff and recategorize. Exactly what the framers had in mind is not clear in several places. There's a heavy emphasis on technique, structure, and definition. That almost has to be at the Bronze level. Progressing to the Silver and Gold levels, a good thing to keep in mind is that the other pillar of The Toyota Way is "Respect for People," weighted just as highly as "Continuous Improvement." That latter phrase in Toyota-speak covers not only TPS, but improvement with design, suppliers, and even environmental sustainability, and that loop takes you back to "Respect for People."

- The difference between the Bronze and the other two is very obvious. I noticed that the Silver and Gold are very similar in the responses as to whether to include the information in the test for that level. In my opinion, the Silver and Gold are very similar with the difference in being the magnitude of understanding and application of the information.

- Survey a little long.

- One of the most important truths to "lean" is that the principles can be applied in many settings. Recently, organizations such as hospitals, governments, and banks have reported benefits from lean techniques. Though the methods are rooted in discrete manufacturing, I think there is an opportunity to be a little more inclusive of all environments, particularly in sections 2, 3, and 4.

- My gut feeling is we are over complicating this. Lean is very basic & simple in concept & very difficult in execution. The execution problem is mostly a people problem & partly a business short term need problem. If we can attack the people "Unlearn & Learn new" problem we have a way to success. If we make all this too technical & "expert" based like six sigma became (my opinion) then we destroy it. I am not a big fan of certification - it tends to become a marketing item rather than a true transformation of the way people think and act. However, I enjoy the questions - makes me think about it more- and I assure you I am no expert (unless you define continual failure as expertise!) Just a part of an organization trying to get better & struggling to do so!

- Responses might be somewhat different depending on whether Bronze certification is a pre-requisite for taking the Silver exam; and likewise Silver certification is a pre-requisite for taking the Gold exam. If that is the case then some of the redundancy could be eliminated.

- Bronze is called a team member level ....A silver is team leader/coordinator level............. A gold is coordinator / change agent level ....I am concerned with HOW the certification is to be awarded it is not only what the knowledge should be. We are developing new leadership thinking.........so need people that can "play" well in front of an audience...with smart busking ....not just "read" the music......... so knowledge without application skills in this environment wont certify anyone to get it done. It should be more of an apprenticeship process than a degree course system. We need qualified leaders with demonstrated certification by doing these things or no-one will follow them....we have seen engineers who are the product of university that have no practical experience get lost once inside the industrial environment...lets not let this happen here... make the scorecard a balance of exam and very practical assessment and demonstrated measured performance in application. It's got to be like the TOP GUN programmed used in the US navy for example... have more thoughts if you want.

Thank you for your time and effort!

Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination?	BRONZE (Tactical)					Necessary for Certification exam?		SILVER (Integrative)					Necessary for Certification exam?		GOLD (Strategic)					Necessary for Certification exam?	
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important		
I. ENABLERS FOR LEAN																					
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	4	3	*2*	1	0	Yes	*No*	4	3	2	1	0	Yes	No	*4*	3	2	1	0	Yes	No
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1.1.1.1 Business Vision	4%	9%	*58%*	26%	3%	23%	77%	10%	*73%*	17%	0%	0%	*93%*	7%	*93%*	7%	0%	0%	0%	*100%*	0%
1.1.1.2 Business Mission	Comments:							Comments:							Comments:						
1.1.1.3 Business Purpose																					
1.1.1.4 Business Values, Philosophy, Ethics																					
1.1.1.5 Strategic Business Assessment																					
1.1.1.6 Strategy Development																					
1.1.1.7 Business Goals and Objectives																					
1.1.1.8 Core Competencies																					
1.1.1.9 Critical Success Factors																					
1.1.2. Respect for Humanity and Social Responsibility	4	3	2	*1*	0	Yes	*No*	4	3	2	1	0	Yes	*No*	*4*	3	2	1	0	Yes	No
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1.1.2.1 Schools and Communities	1%	4%	25%	*55%*	14%	14%	*86%*	3%	16%	*53%*	16%	3%	28%	*82%*	*42%*	48%	7%	3%	0%	*87%*	13%
1.1.2.2 Unions								Comments:							Comments:						
1.1.2.3 Other Stakeholders																					
1.1.3. Long and Short-term Planning	4	3	*2*	1	0	*Yes*	No	4	3	2	1	0	*Yes*	No	*4*	3	2	1	0	*Yes*	No
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1.1.3.1 Hoshin Planning & Policy Deployment	0%	22%	*61%*	17%	0%	*85%*	15%	17%	*78%*	5%	0%	0%	*100%*	0%	*70%*	21%	8%	1%	0%	*100%*	0%
1.1.3.2 Execution and Metrics	Comments:							Comments:							Comments:						
1.1.3.3 Project Management																					

Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination?	BRONZE (Tactical)			SILVER (Integrative)			GOLD (Strategic)		
	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important		Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important		Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important		Necessary for Certification exam?
I. ENABLERS FOR LEAN									
1.1.4. Principles of Lean leadership	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐		Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐		Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐		Yes ☐ No ☐
1.1.4.1 Go and See	77% 20% 3% 0% 0%		*99%* 1%	91% 9% 0% 0% 0%		*100%* 0%	99% 0% 1% 0% 0%		*97%* 3%
1.1.4.2 Defining Value vs Non-value 1.1.4.3 Identifying Waste 1.1.4.4 Achieving Flow 1.1.4.5 Recognizing Normal vs Abnormal 1.1.4.6 Respect for Humanity	**Comments:**			**Comments:**			**Comments:**		
1.1.5. Lean corporate culture	4 **3** 2 1 0 ☐ ☐ ☐ ☐ ☐		Yes ☐ No ☐	**4** 3 2 1 0 ☐ ☐ ☐ ☐ ☐		Yes ☐ No ☐	**4** 3 2 1 0 ☐ ☐ ☐ ☐ ☐		Yes ☐ No ☐
1.1.5.1 Value Stream Mapping	24% *57%* 19% 0% 1%		*93%* 7%	*83%* 16% 1% 0% 0%		*99%* 1%	*91%* 6% 3% 0% 0%		*100%* 5%
1.1.5.2 Kaizen Blitz Events 1.1.5.3 Continuous Improvement & Change 1.1.5.4 Communication of Business Values, Philosophy, Ethics 1.1.5.5 Change & knowledge management systems 1.1.5.6 Resource Standards & Measures for Business Results	**Comments:**			**Comments:**			**Comments:**		
1.2.1. Principles of empowerment	4 3 **2** 1 0 ☐ ☐ ☐ ☐ ☐		Yes ☐ No ☐	4 **3** 2 1 0 ☐ ☐ ☐ ☐ ☐		Yes ☐ No ☐	**4** 3 2 1 0 ☐ ☐ ☐ ☐ ☐		Yes ☐ No ☐
1.2.1.1 Communication	4% 17% *58%* 16% 4%		*68%* 32%	18% *73%* 9% 0% 0%		*99%* 1%	*94%* 4% 2% 0% 0%		*97%* 3%
1.2.1.2 Delegation 1.2.1.3 Recognition 1.2.1.4 Rewards 1.2.1.5 Employee Satisfaction & Morale 1.2.1.6 Employee & Labor Relations	**Comments:**			**Comments:**			**Comments:**		

Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination? **I. ENABLERS FOR LEAN**	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?	
1.2.2. Employee training and development	4 ☐	3 ☐	*2* ☐	1 ☐	0 ☐	*Yes* ☐	No ☐	4 ☐	*3* ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐	No ☐	*4* ☐	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐	No ☐
1.2.2.1 Instructional Goals	4%	30%	*48%*	17%	0%	*62%*	38%	20%	*73%*	7%	0%	0%	*99%*	1%	*83%*	15%	1%	1%	0%	*99%*	1%
1.2.2.2 Skills Assessment 1.2.2.3 Continuous Learning Strategy 1.2.2.4 Cross-Training 1.2.2.5 Classroom and On-the-Job Training 1.2.2.6 Coaching & Mentoring	Comments:							Comments:							Comments:						
1.2.3. Teamwork	4 ☐	3 ☐	*2* ☐	1 ☐	0 ☐	*Yes* ☐	No ☐	*4* ☐	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐	No ☐	*4* ☐	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐	No ☐
1.2.3.1 Cross-Functional Team Selection & Leadership	9%	35%	*50%*	7%	0%	*87%*	13%	*75%*	23%	2%	0%	0%	*100%*	0%	*83%*	16%	1%	0%	0%	*99%*	1%
1.2.3.2 Multi-Level Participation 1.2.3.3 Roles & Responsibilities 1.2.3.4 Decision-Making Types 1.2.3.5 Team Dynamics (Storming, norming, etc.)	Comments:							Comments:							Comments:						
1.2.4. Suggestion/Feedback/ Appraisal System	4 ☐	3 ☐	*2* ☐	1 ☐	0 ☐	*Yes* ☐	No ☐	4 ☐	*3* ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐	No ☐	*4* ☐	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐	No ☐
1.2.4.1 Information Sharing	6%	23%	*47%*	21%	3%	*58%*	42%	15%	*67%*	16%	2%	0%	*91%*	9%	*80%*	18%	2%	0%	0%	*99%*	1%
	Comments:							Comments:							Comments:						

Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination?	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?	
I. ENABLERS FOR LEAN	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
1.2.5. Employee Turnover, Absenteeism and Compensation	1%	13%	32%	48%	6%	15%	85%	4%	43%	49%	4%	0%	36%	64%	54%	35%	9%	2%	0%	84%	16%
Comments:																					
1.2.6. Ergonomic, clean and safe work environment, and results 1.2.6.1 Environment 1.2.6.2 Ergonomics 1.2.6.3 Safety	70%	28%	1%	1%	0%	97%	3%	77%	22%	1%	0%	0%	99%	1%	84%	13%	1%	2%	0%	92%	8%
Comments:																					
Additional Areas from Pre-Delphi																					
Motivation Theory	7%	13%	34%	27%	4%	25%	75%	16%	40%	24%	8%	7%	69%	31%	47%	28%	13%	3%	9%	80%	20%
Comments:																					
Socio-technical Systems (An approach to design work that involves the interaction between people & technology at workplace)	5%	18%	28%	34%	15%	27%	73%	15%	39%	25%	15%	6%	62%	38%	31%	35%	25%	6%	3%	73%	28%
Comments:																					

Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination? **II. LEAN CORE OPERATIONS**	BRONZE (Tactical)								SILVER (Integrative)								GOLD (Strategic)							
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	| Necessary for Certification exam?			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	| Necessary for Certification exam?			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	| Necessary for Certification exam?		
2.1.1. Operational Vision and Strategy	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐		*No* ☐	4 ☐	*3* ☐	2 ☐	1 ☐	0 ☐	Yes ☐		No ☐	*4* ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐		No ☐
2.1.1.1 Operation Processes Vision, Mission, Strategy & Goals	1%	11%	*63%*	23%	2%	25%		*75%*	13%	*71%*	16%	0%	0%	*95%*		5%	93%	7%	0%	0%	0%	*100%*		0%
2.1.1.2 Lean Principles in Strategy	Comments:								Comments:								Comments:							
2.1.1.3 Empowerment in Strategy																								
2.1.1.4 Operational Alignment with Organizational Vision, Mission, Strategy & Goals																								
2.2.1 Product Design and Development	4 ☐	3 ☐	*2* ☐	1 ☐	0 ☐	Yes ☐		*No* ☐	4 ☐	*3* ☐	2 ☐	1 ☐	0 ☐	Yes ☐		No ☐	*4* ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐		No ☐
2.2.1.1 Quality Function Deployment	3%	15%	*58%*	23%	1%	49%		*51%*	13%	*73%*	14%	0%	0%	*94%*		6%	*75%*	22%	3%	0%	0%	*96%*		4%
2.2.1.2 Concurrent Engineering	Comments:								Comments:								Comments:							
2.2.1.3 Variety Reduction																								
2.2.1.4 Engineering Changes																								
2.2.1.5 Design for Manufacture & Assembly																								
2.2.1.6 Design for Product Life Cycle (DFx)																								
2.2.1.7 Failure Mode & Effects Analysis (FMEA)																								
2.2.1.8 Life Cycle Engineering																								
2.2.1.9 Production Process Preparation (3P)																								
2.2.1.10 Knowledge Transfer Methods & Practices																								

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Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination?	BRONZE (Tactical)					Necessary for Certification exam?		SILVER (Integrative)					Necessary for Certification exam?		GOLD (Strategic)					Necessary for Certification exam?	
II. LEAN CORE OPERATIONS	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important		
2.2.2. Product Market Service	4	3	2	*1*	0	Yes	*No*	4	3	2	1	0	Yes	No	*4*	3	2	1	0	Yes	No
2.2.2.1 Customer Feedback & Market Needs Analysis	1%	9%	33%	**44%**	13%	25%	75%	7%	**47%**	33%	13%	0%	60%	40%	**52%**	34%	14%	0%	0%	**90%**	10%
2.2.2.2 Customer Specs and Requirements 2.2.2.3 New market development & current market exploitation 2.2.2.4 E-commerce systems 2.2.2.5 Benchmarking	Comments:							Comments:							Comments:						
2.3.1. Suppliers	4	*3*	2	1	0	Yes	*No*	4	*3*	2	1	0	Yes	No	*4*	3	2	1	0	Yes	No
2.3.1.1 Supplier Development Processes	11%	**59%**	27%	3%	0%	25%	75%	9%	**73%**	17%	1%	0%	96%	4%	80%	20%	0%	0%	0%	99%	1%
2.3.1.2 Supplier Certification 2.3.1.3 Supplier Benchmarking 2.3.1.4 Supplier Satisfaction Measures 2.3.1.5 Corrective Action System	Comments:							Comments:							Comments:						
2.3.2 Customers	4	3	2	*1*	0	Yes	No	4	*3*	2	1	0	Yes	No	*4*	3	2	1	0	Yes	No
2.3.2.1 Customer Training & Development Processes	0%	12%	32%	**50%**	6%	43%	57%	13%	**57%**	30%	0%	0%	93%	7%	75%	23%	2%	0%	0%	*100%*	0%
2.3.2.2 Customer Selection Focus 2.3.2.3 Demand Load Leveling 2.3.2.4 Corrective Action System	Comments:							Comments:							Comments:						

Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination? **II. LEAN CORE OPERATIONS**	BRONZE (Tactical)			SILVER (Integrative)			GOLD (Strategic)		
	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important	Necessary for Certification exam?		Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important	Necessary for Certification exam?		Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important	Necessary for Certification exam?	
2.3.3. Distribution & Transport Alliances	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐	*No* ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	*Yes* ☐	No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐	No ☐
2.3.3.1 Warehousing	1% 0% *60%* 36% 2%	25%	75%	4% *70*% 23% 3% 0%	90 %	10%	62% 32% 4% 2% 0%	99%	1%
2.3.3.2 Distribution Centers	Comments:			Comments:			Comments:		
2.3.3.3 Cross-Docks									
2.3.3.4 Reverse Logistics									
2.3.3.5 Remanufacturing/ Maintenance, Repair and Overhaul (MRO)									
2.3.3.6 Just-in-Time Alliances									
2.3.3.7 Supplier Managed Inventory Systems									
2.4.1. Systematic identification and elimination of waste	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐	No ☐	*4* 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐	No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐	No ☐
2.4.1.1 Waste Identification and elimination of waste	92% 6% 1% 1% 0%	99 %	1%	90% 9% 1% 0% 0%	100 %	0%	90% 10% 0% 0% 0%	94 %	6%
2.4.1.2 Value Stream Mapping	Comments:			Comments:			Comments:		
2.4.1.3 Value Analysis									
2.4.1.4 5S Standards & Discipline									
2.4.1.5 Visual Workplace									
2.4.1.6 Kaizen Blitz Events									
2.4.1.7 Mistake Proofing									
2.4.1.8 Source Inspection									
2.4.1.9 Continuous Improvement									
2.4.1.10 Five Why's Problem Solving									

Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination? II. LEAN CORE OPERATIONS	BRONZE (Tactical)					Necessary for Certification exam?		SILVER (Integrative)					Necessary for Certification exam?		GOLD (Strategic)					Necessary for Certification exam?	
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important		
2.4.2. Just-in-Time Operations	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐
2.4.2.1 Takt Time	85%	15%	0%	0%	0%	99 %	1%	90%	10%	0%	0%	0%	100 %	0%	85%	13%	2%	0%	0%	91 %	9%
2.4.2.2 Material Signals 2.4.2.3 Pull System 2.4.2.4 Continuous Flow 2.4.2.5 Just-in-Time (JIT) 2.4.2.6 Setup Reduction (SMED) 2.4.2.7 Total Productive Maintenance (TPM) 2.4.2.8 Load-Leveling (Heijunka)	Comments:							Comments:							Comments:						
2.4.3. Cellular & Continuous Flow	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐
2.4.3.1 Cellular Manufacturing	80%	18%	2%	0%	0%	97 %	3%	90%	10%	0%	0%	0%	100%	0%	80%	15%	4%	1%	0%	93 %	7%
2.4.3.2 One Piece Flow 2.4.3.3 Standard Work 2.4.3.4 Multi-process Handling 2.4.3.5 Autonomation 2.4.3.6 Production Schedule 2.4.3.7 Bills of Materials 2.4.3.8 Routings 2.4.3.9 Flow Analysis Charts	Comments:							Comments:							Comments:						

	BRONZE (Tactical)			SILVER (Integrative)			GOLD (Strategic)		
Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination? **II. LEAN CORE OPERATIONS**	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important		Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important		Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important		Necessary for Certification exam?
2.4.4. Lean Tools for Continuous Improvement	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐		Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐		Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐		Yes ☐ No ☐
2.4.4.1 Plan-Do-Check-Act	83% 15% 2% 0% 0%		96 % 4%	86% 12% 2% 0% 0%		99 % 1%	83% 13% 4% 0% 0%		92 % 8%
2.4.4.2 Reliability & maintainability 2.4.4.3 Root Cause & Corrective Action 2.4.4.4 Flow Charting 2.4.4.5 Pareto 2.4.4.6 Cause & effect Diagrams 2.4.4.7 Check Sheets 2.4.4.8 Histograms 2.4.4.9 Scatter & Concentration Diagrams 2.4.4.10 Control Charts 2.4.4.11 Problem Solving Storyboards	Comments:			Comments:			Comments:		
Additional Areas from Pre-Delphi									
Six Sigma/Problem Solving Techniques	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐		Yes ☐ *No* ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐		Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐		Yes ☐ No ☐
	13% 21% **38%** 22% 6%		42 % 58%	29% **37%** 23% 6% 5%		74 % 26%	**50%** 34% 9% 1% 6%		80 % 20%
	Comments:			Comments:			Comments:		
Quantitative Decision Making Techniques	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐		Yes ☐ *No* ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐		Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐		Yes ☐ No ☐
	8% 22% **38%** 22% 10%		38 % 62%	23% **47%** 23% 5% 2%		72 % 28%	**54%** 30% 12% 3% 1%		82 % 18%
	Comments:			Comments:			Comments:		

256

II. Additional Areas from Pre-Delphi	BRONZE (Tactical)		SILVER (Integrative)		GOLD (Strategic)	
	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?
Simulation Technique	4 3 2 *1* 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ *No* ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	*Yes* ☐ No ☐	4 *3* 2 1 0 ☐ ☐ ☐ ☐ ☐	*Yes* ☐ No ☐
	3% 12% 29% *40%* 16%	19% *81%*	12% *35%* 33% 16% 4%	52% 48%	20% *40%* 23% 13% 4%	55% 45%
	Comments:		Comments:		Comments:	
Optimization Techniques	4 3 2 *1* 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ *No* ☐	4 3 *2* 1 0 ☐ ☐ ☐ ☐ ☐	*Yes* ☐ No ☐	4 *3* 2 1 0 ☐ ☐ ☐ ☐ ☐	*Yes* ☐ No ☐
	1% 19% 27% *34%* 18%	24% *76%*	16% 34% *38%* 9% 3%	55% 45%	28% *34%* 27% 6% 5%	65% 35%
	Comments:		Comments:		Comments:	
Facilities Design and Layout	4 3 *2* 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ *No* ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	*Yes* ☐ No ☐	*4* 3 2 1 0 ☐ ☐ ☐ ☐ ☐	*Yes* ☐ No ☐
	10% 24% *39%* 22% 5%	48% *52%*	32% *38%* 22% 8% 0%	80% 20%	*50%* 23% 27% 0% 0%	82% 18%
	Comments:		Comments:		Comments:	
III. BUSINESS CORE OPERATIONS-SUPPORT FUNCTIONS	BRONZE (Tactical)		SILVER (Integrative)		GOLD (Strategic)	
	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?
3.1.1 Administrative Vision & Strategy	4 3 *2* 1 0 ☐ ☐ ☐ ☐ ☐	*Yes* ☐ No ☐	4 *3* 2 1 0 ☐ ☐ ☐ ☐ ☐	*Yes* ☐ No ☐	*4* 3 2 1 0 ☐ ☐ ☐ ☐ ☐	*Yes* ☐ No ☐
3.1.1.1 Application of Lean principles & techniques	6% 18% *61%* 14% 1%	*76%* 25%	20% *71%* 9% 0% 0%	*99%* 1%	*90%* 10% 0% 0% 0%	*100%* 0%
3.1.1.2 Focus on value adds & waste identification & elimination 3.1.1.3 Commitment to Continuous Improvement 3.1.1.4 Business operations improvement metrics	Comments:		Comments:		Comments:	

III. BUSINESS CORE OPERATIONS-SUPPORT FUNCTIONS	BRONZE (Tactical) Importance					Necessary for Cert. exam?		SILVER (Integrative) Importance					Necessary for Cert. exam?		GOLD (Strategic) Importance					Necessary for Cert. exam?	
	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
3.1.2. Alignment & Systematic Business & Service Process Design	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
3.1.2.1 Finance & Accounting: Measurement & control systems,etc	1%	5%	60%	30%	4%	15%	86%	10%	66%	24%	0%	0%	87%	13%	85%	15%	0%	0%	0%	99%	1%

3.1.2.2 Human Resources: Alignment of selection, development, teamwork, performance feedback & discipline, compensation & rewards, etc.

3.1.2.3 Materials Management:Inventory Control,planning&scheduling,logistics, etc

3.1.2.4 Information Technology:Appropriate alignment with process changes, accessibility,etc

3.1.2.5 Sales&Marketing:Alignment of sales&operations planning&execution,etc

3.1.2.6 Quality Assurance: Regulation & certification, inspection rationale, etc

3.2.1.7 Process & Manufacturing Engineering: System for engineering changes, concurrent

3.2.1.8 Legal & Regulatory: Alignment with core lean thinking, etc

Comments:

Category	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
Supply Chain Logistics	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	5%	3%	52%	32%	8%	24%	76%	10%	54%	28%	6%	2%	80%	20%	50%	39%	10%	1%	0%	90%	10%

Comments:

Category	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
Lean Accounting	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	3%	4%	33%	44%	11%	25%	75%	10%	40%	36%	10%	4%	62%	38%	55%	32%	11%	1%	0%	96%	4%

Comments:

Category	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	8%	6%	42%	34%	10%	25%	75%	14%	36%	41%	3%	4%	65%	35%	43%	32%	19%	1%	5%	78%	22%

Comments:

Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination?	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?	
IV. QUALITY, COST & DELIVERY MEASURES																					
4.1.1 Quality Results	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐
4.1.1.1 Rework	73%	15%	10%	1%	1%	91%	9%	77%	16%	6%	0%	1%	97%	3%	78%	13%	7%	0%	2%	93%	7%
4.1.1.2 Customer PPM Rejects 4.1.1.3 First Pass Yield 4.1.1.4 Scrap 4.1.1.5 Process Variation 4.1.1.6 Cost of Quality 4.1.1.7 Warranty Costs	Comments:							Comments:							Comments:						
4.2.1 Cost & Productivity Results	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐
4.2.1.1 Inventory Turns	61%	29%	9%	1%	0%	96%	4%	90%	9%	1%	0%	0%	99%	1%	87%	10%	2%	1%	0%	97%	3%
4.2.1.2 Record Accuracy 4.2.1.3 Cycle Time, Takt Time and Throughput Time 4.2.1.4 Operational Equipment Effectiveness (OEE) 4.2.1.5 Labor Value-Add 4.2.1.6 Product Cost Reduction 4.2.1.7 Changeover 4.2.1.8 Resource Utilization 4.2.1.9 Energy Efficiency 4.2.1.10 Performance to Load Leveling	Comments:							Comments:							Comments:						

Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination?	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?	
IV. QUALITY, COST & DELIVERY MEASURES	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
4.3.1 Delivery and Customer Service Measurement	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
4.3.1.1 Line-Items Delivered On-Time to Customer Requirement	15%	49%	27%	9%	0%	81%	19%	54%	40%	3%	3%	0%	96%	4%	80%	16%	1%	3%	0%	93%	7%
4.3.1.2 Complete Orders Delivered On-Time to Customer Requirements 4.3.1.4 Premium Freight 4.3.1.5 Mistakes in Shipment 4.3.1.6 Warranty Response, Service, etc.	Comments:							Comments:							Comments:						
Additional Areas from Pre-Delphi																					
International Organization for Standardization (ISO) and Lean	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐
	5%	12%	38%	33%	12%	25%	75%	19%	28%	32%	15%	6%	65%	35%	43%	27%	18%	6%	6%	75%	25%
	Comments:							Comments:							Comments:						
Quality Management System (QMS)	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐
	7%	13%	46%	25%	9%	35%	65%	16%	37%	31%	8%	8%	71%	29%	45%	33%	14%	3%	5%	78%	22%
	Comments:							Comments:							Comments:						

	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination?	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam? Yes	No	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam? Yes	No	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam? Yes	No
5.1.1 Customer Satisfaction Results	4	3	2	1	0	Yes	*No*	4	*3*	2	1	0	*Yes*	No	*4*	3	2	1	0	*Yes*	No
5.1.1.1 Market Share	0%	6%	*61%*	30%	3%	13%	87%	6%	*65%*	29%	0%	0%	84%	16%	*81%*	19%	0%	0%	0%	*100%*	0%
5.1.1.2 Reorder Rate 5.1.1.3 Customer Survey Results 5.1.1.4 Customer Audit Results 5.1.1.5 Other Customer Feedback 5.1.1.6 Value/Improvement Analysis 5.1.1.7 Customer Retention 5.1.1.8 Customer Awards	Comments:							Comments:							Comments:						
5.2.1. Profitability Measurement	4	3	2	*1*	0	Yes	*No*	4	3	2	1	0	*Yes*	No	*4*	3	2	1	0	*Yes*	No
5.2.1.1 Operating Income on Sales & Assets	2%	4%	32%	*52%*	10%	10%	90%	9%	*55%*	32%	4%	0%	83%	17%	89%	9%	1%	1%	0%	98%	2%
5.2.1.2 Operating Income on Space 5.2.1.3 Fixed & Variable Costs 5.2.1.4 Cash Flow 5.2.1.5 Value Stream Profitability	Comments:							Comments:							Comments:						
Additional Areas from Pre-Delphi																					
Lean Business Metrics	4	3	*2*	1	0	Yes	*No*	4	3	2	1	0	*Yes*	No	*4*	3	2	1	0	*Yes*	No
	3%	21%	*44%*	17%	15%	46%	54%	22%	*51%*	17%	3%	7%	85%	15%	*71%*	23%	0%	2%	4%	91%	9%
	Comments:							Comments:							Comments:						
Total Supply Chain Cost	4	3	2	*1*	0	Yes	*No*	4	*3*	2	1	0	*Yes*	No	*4*	3	2	1	0	*Yes*	No
	2%	8%	36%	*38%*	16%	23%	77%	12%	*47%*	35%	5%	1%	70%	30%	*51%*	39%	8%	1%	1%	88%	12%
	Comments:							Comments:							Comments:						

Additional Comments if Any:

Thank you for your time and effort!

Subject: Delphi Round Two Reminder

Dear Lean Delphi Panel Expert:

We recently sent out the Round Two Delphi questionnaire for our Lean Certification Role Delineation Study. We are looking forward to your continued participation as a Delphi panel expert in our study. If you have not yet had a chance to complete the Round Two questionnaire, please try to do so and mail it back to me as soon as possible.

If you have not yet received the Round Two questionnaire, please email me at: hiral.shah@emich.edu along with your complete address and I will send one to you immediately. *If you prefer filling in an electronic format, then please email me and I will send you an electronic copy of the survey.*

We hope to receive replies from all members of Delphi panel by mid-April. We can then analyze the information and report the Round Two results back to you with the final Round Three questionnaire in early May.

Your contribution and commitment to our study is most valued, and is essential to assuring validity in this research to create a standardized body of knowledge for the Lean manufacturing discipline. We very much appreciate your time, effort, and contribution.

Thank you in advance!

Sincerely,

Ms. Hiral Shah, Researcher   **Dr. Tracy Tillman, CMfgE, CEI/CEM**
Eastern Michigan University   Chair, Ph.D. Dissertation Committee
hiral.shah@emich.edu   Eastern Michigan University

Sub: Lean Delphi Round Two Reminder   **Date: Apr. 12, 2007**

Dear Lean Delphi Panel Expert,

We hope that you received the Round Two questionnaire for our Delphi study along with the results obtained from Round One, sent a few weeks ago. The objective of our study is to delineate a standardized body of knowledge for the SME/AME/Shingo Lean manufacturing certification program. If you have not already done so, please take a few minutes to complete the Round Two Delphi questionnaire that you received and return it to me as soon as possible.

If you need or prefer to use an electronic version of the survey, then please email me at hiral.shah@emich.edu and I will email one to you immediately.

This study is ground breaking and the first of its kind, the results of which will lead to many future developments in our discipline. Your professional expertise in Lean manufacturing is indeed a significant contribution not only to our study, but also to many other organizations and individuals who are on their path to obtain success in their lean related endeavors. We seek your continued participation in this study and sincerely appreciate your time and effort involved in this research venture.

Respectfully,

Ms. Hiral Shah, Researcher   Dr. Tracy Tillman, Dissertation Chair
Eastern Michigan University   Eastern Michigan University

Subject: Lean Delphi Study -- Round Two Reminder

Dear :

Recently we sent you Round Two Delphi questionnaire for our Lean Certification Role Delineation Study, but did not receive your response. We are looking forward to your participation as a Delphi panel expert in our study.

In order to expedite the process, I have attached an electronic copy of the survey along with the results from Round One. Please take a few moments to complete the questionnaire and email me back your responses at your earliest.

After receiving your responses, we can send out the final round of the study in early May. Your participation and expertise is very valuable in order to assure validity in this research and to create a standardized body of knowledge for the Lean manufacturing discipline.

We are extremely thankful to you for your interest and participation in this study and very much value your time and efforts involved.

We look forward to your responses.

Sincerely,

Ms. Hiral Shah, Researcher   **Dr. Tracy Tillman, CMfgE, CEI/CEM**
Eastern Michigan University   Chair, Ph.D. Dissertation Committee
hiral.shah@emich.edu   Eastern Michigan University

P.S. If you have already mailed in your responses then please ignore this email.

Appendix H

Round Three of the Delphi Study

May 10, 2007

Dear :

Thank you very much for your valuable and thoughtful responses in Round Two of our Delphi study. As an overview, the goal of our study is to validate and refine the body of knowledge that forms a framework for the Lean Manufacturing certification program, developed jointly by the Society of Manufacturing Engineers (SME), Shingo Prize for Excellence (Shingo), and Association for Manufacturing Excellence (AME). This study is ground breaking and the first of its kind, the results of which will lead to many future developments and refinements in our discipline.

We achieved a 78% response rate in Round Two of our study, which demonstrates an overwhelming level of support and contribution from our group. The commitment and enthusiasm of our panel members is impressive! For example, one panelist responded to the survey while serving in Iraq, and another panelist responded while in recovery from surgery. Moreover, many of our panelists took time out of their busy schedules, whether working on important projects or traveling, to respond to our study in a timely manner. Your support and feedback to our study provides further encouragement and assurance to us that our study will be a significant contribution to the field of Lean manufacturing.

We look forward your continued participation and contribution to our research in Round Three, which is the final round of our study. For your reference, our panelists' Round Two responses and comments are shown in a separate document titled "Round Two Results." If you prefer to fill out an electronic copy of our final Round Three questionnaire, please email me at: hiral.shah@emich.edu

As a brief review, the three levels of the Lean Certification program are described below:

1. Bronze (tactical level) – Candidates should understand tactical implementation of lean principles and tools to drive improvements.

2. Silver (integrative level) – Candidates should know how to apply lean principles and tools at the value stream level, understand lean enterprise integration, and teach lean integration.

3. Gold (strategic level) – Candidates should know how to apply lean principles and tools to achieve significant business results, understand strategic enterprise transformation, teach lean strategy leadership, and have a strategic focus.

As you fill in your responses, please note that at the Silver and Gold level, it is required that a candidate has some mentoring and coaching experience in lean. Although candidates can apply directly for the Gold level, they are still required to complete the exam and portfolio for Bronze and Silver before they can take the Gold exam. (For more information on the certification/Body of knowledge visit: http://sme.org/certification)

A short overview of the process for our Delphi study is delineated as follows:

1. Pre-Delphi survey – identify experts for the study and identify a generalized opinion on the topic from a larger population. (Completed)

2. Round I – review the results of the Pre-Delphi survey and rate the importance of topics, with comments provided by the experts on the panel. (Completed)

3. Round II – review the results of Round I and refine ratings of importance of topics, with additional comments provided by the experts on the panel. (Completed)

4. Round III *(current round)* – review the refined results of Round II and seek final rating of topics, with concluding comments provided by the experts on the panel. All Delphi panelists will receive the final results of the study.

Please take a few minutes to complete this Round Three questionnaire and send it back to me within two weeks of receiving it. For each competency area, provide your rating on a five point scale of importance: (4) extremely important, (3) very important, (2) moderately important, (1) slightly important, and (0) not important. Also rate if the competency area is necessary for the certification exam on a dichotomous scale: Yes – No. In other words consider, *how important is it for the candidate to possess the competency? Should the competency be included in the certification examination?*

When contemplating your response, consider the responses given by the participants from Round Two, shown as percent of concurrence and modal response to each competency area, and percent response to the question regarding the competency area being necessary for certification. In addition to providing comments on specific competency area, you may respond to any comments presented by other panel experts. Your responses will be kept anonymous.

If your rating of a competency area is two or more categories away from the group's modal rating, please provide an explanation of your opinion for your associate panel member. Additional space is also provided to give your additional or general comments on the study at the end of the questionnaire.

Your thoughtful responses based upon your experience are very valuable—not only to us, but also to many others in our discipline. We sincerely appreciate your commitment and time involved in the study and look forward to your continued participation in the final round of our study.

Respectfully,

Ms. Hiral Shah, CEI/CEM, CAPM   Dr. Tracy Tillman, CEI/CEM, CMfgE
Ph.D. Fellow   Chair, Ph.D. Dissertation Committee
Eastern Michigan University   Eastern Michigan University

SME/AME/SHINGO LEAN CERTIFICATION ROLE DELINEATION STUDY
Results of Round Two Delphi

Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination?	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?	

I. ENABLERS FOR LEAN

1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	4	3	2	1	0	Yes	*No*	4	*3*	2	1	0	*Yes*	No	*4*	3	2	1	0	*Yes*	No
	☐	☐	■	☐	☐	☐	■	☐	■	☐	☐	☐	■	☐	■	☐	☐	☐	☐	■	☐

1.1.1.1 Business Vision	0%	7%	*72%*	19%	2%	16%	*84%*	5%	*83%*	12%	0%	0%	*100%*	0%	*100%*	0%	0%	0%	0%	*100%*	0%

1.1.1.2 Business Mission
1.1.1.3 Business Purpose
1.1.1.4 Business Values, Philosophy, Ethics
1.1.1.5 Strategic Business Assessment
1.1.1.6 Strategy Development
1.1.1.7 Business Goals and Objectives
1.1.1.8 Core Competencies
1.1.1.9 Critical Success Factors

BRONZE Comments: - *Alignment with company goals and plans is crucial to doing the right things with limited resources.*
- *Application of principles is the focus.*

- *At this level, they don't need to know how to set missions, visions, etc., but they should know what they are, and that they should connect to metrics -- also that mission, values, and vision are a guide when you must take action other than "standard work."*
- *This is not tactical but more strategic.*
- *Moderately important due to criticality of these elements in the success of Lean in an organization.*
- *Do not need much depth, but everyone should know how Lean fits into the business--understanding of the business vision, mission and purpose and how Lean is an essential element.*

SILVER Comments: - *Need basic understanding.*
- *This level needs a little more emphasis on these topics.*

GOLD Comments: - *Must have business vision/goals.*
- *Integral part of BOK.*
- *Emphasis on not only what they are, but how they fit together, and how they are established.*

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1.1.2. Respect for Humanity and Social Responsibility	4 3 2 **1** 0 Yes **No** ☐ ☐ ☐ ■ ☐ ☐ ■	4 3 **2** 1 0 Yes **No** ☐ ☐ ■ ☐ ☐ ☐ ■	**4** 3 2 1 0 **Yes** No ■ ☐ ☐ ☐ ☐ ■ ☐
1.1.2.1 Schools and Communities	2% 9% 21% *64%* 4% 7% *93%*	5% 18% *68%* 9% 0% 25% 75%	50% 43% 7% 0% 0% *94%* 6%
1.1.2.2 Unions 1.1.2.3 Other Stakeholders	**Comments:** - *This is always important.* - *Tactical implementation requires buy-in which requires good communication and people skills.* - *NA for this level.* - *We need to make sure there is balance with the human element. We cannot afford to dehumanize work.* - *I'm out of step here, but Respect for People is one of the twin pillars of the Toyota Way. Few questions are needed, however. How does an exam test for attitude?*	**Comments:** - *Union conflicts will probably occur at the value stream level.* - *Make or break for successful integration of value stream elements.* - *Very little application.* - *The concept of leadership shifts to coaching and to developing people. Need to know how to "cross union lines" behaviorally.* - *I feel that '2' is a minimum starting competency for this area. The positive impact of Lean on these groups is important.*	**Comments:** - *This area is critical to ethical, socially responsible business.* - *Should respect shareholders.* - *Emphasis is on the impact.* - *Have to think of the company as its people, not as a machine. Those inept with people should not become gold-certified.* - *Must be well aware of the respect for humanity and social responsibility connected directly with Lean.* - *Union involvement is critical element.*
1.1.3. Long and Short-term Planning	4 3 **2** 1 0 **Yes** No ☐ ☐ ■ ☐ ☐ ■ ☐	4 **3** 2 1 0 **Yes** No ☐ ■ ☐ ☐ ☐ ■ ☐	**4** 3 2 1 0 **Yes** No ■ ☐ ☐ ☐ ☐ ■ ☐
1.1.3.1 Hoshin Planning & Policy Deployment	0% 12% *79%* 9% 0% *86%* 14%	14% *82%* 4% 0% 0% *100%* 0%	*96%* 4% 0% 0% 0% *100%* 0%
1.1.3.2 Execution and Metrics 1.1.3.3 Project Management	**Comments:** - *Familiarity with concepts.* - *More a follower at this stage-much else to learn.* - *Hoshin awareness.* - *Basic definitions should be known. Everyone needs a little knowledge of project management.* - *Execution & Metrics and are important competencies at this level.* - *Test only on 1131/1132.*	**Comments:** - *Critical practical skill.* - *Need as user and compose.* - *A little more on execution and metrics here.* - *Execution & Metrics and Project Management are important at this level.*	**Comments:** - *Critical practical skill.* - *Need user level, composition.* - *More emphasis on hoshin at this level.*

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Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination?	BRONZE (Tactical)				SILVER (Integrative)				GOLD (Strategic)			
	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important			Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important			Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important			Necessary for Certification exam?
I. ENABLERS FOR LEAN												
1.1.4. Principles of Lean leadership	*4* ■	3 ☐ 2 ☐ 1 ☐ 0 ☐		*Yes* ■ No ☐	*4* ■	3 ☐ 2 ☐ 1 ☐ 0 ☐		*Yes* ■ No ☐	*4* ■	3 ☐ 2 ☐ 1 ☐ 0 ☐		*Yes* ■ No ☐
1.1.4.1 Go and See	93%	7% 0% 0% 0%		100% 0%	97%	3% 0% 0% 0%		100% 0%	96%	0% 2% 2% 0%		95% 5%
1.1.4.2 Defining Value vs. Non-value 1.1.4.3 Identifying Waste 1.1.4.4 Achieving Flow 1.1.4.5 Recognizing Normal vs. Abnormal 1.1.4.6 Respect for Humanity	**Comments:** - *All are important, but Go & See is very important.* - *Awareness.* - *Basics, definitely.*				**Comments:** - *All are important, but Go & See is very important.* - *Required for fundamental knowledge.* - *More basics.*				**Comments:** - *All are important, but Go & See is very important.* - *Already tested at lower levels. Senior leaders must encourage enable and practice "Go See".* - *Already test twice. No need to test again.* - *Must be.* - *Everything except respect for humanity should be down pat by this point.* - *Extremely important, but should be covered sufficiently in bronze/silver level exams.* - *These are the 'basics' of Lean and would have been covered in previous levels.*			

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1.1.5. Lean corporate culture	4 3 2 1 0	Yes	No	4 3 2 1 0	Yes	No	4 3 2 1 0	Yes	No
	☐ ■ ☐ ☐ ☐	■	☐	■ ☐ ☐ ☐ ☐	■	☐	■ ☐ ☐ ☐ ☐	■	☐
1.1.5.1 Value Stream Mapping	22% 66% 12% 0% 0%	95%	5%	88% 12% 0% 0% 0%	100%	0%	98% 2% 0% 0% 0%	100%	0%
1.1.5.2 Kaizen Blitz Events 1.1.5.3 Continuous Improvement & Change 1.1.5.4 Communication of Business Values, Philosophy, Ethics 1.1.5.5 Change & knowledge management systems 1.1.5.6 Resource Standards & Measures for Business Results	**Comments:** - *Kaizen get everyone involved.* *- Test 1.1.5.1.2. Mixed category for exam purposes.* *- Awareness.* *- Basics, emphasize the first three.* *- Culture is essential for success and everyone is responsible*			**Comments:** - *Test 1.1.5.3.4* *- Required for fundamentals.* *- More emphasis on values, philosophy, ethics, and knowledge management than at Bronze Level.*			**Comments:** - *Test 1.1.5.5.6* *- Must be.* *- The first three items should be down pat. Emphasize the last three.*		

1.2.1. Principles of empowerment	4 3 2 1 0	Yes	No	4 3 2 1 0	Yes	No	4 3 2 1 0	Yes	No
	☐ ☐ ■ ☐ ☐	■	☐	☐ ■ ☐ ☐ ☐	■	☐	■ ☐ ☐ ☐ ☐	■	☐
1.2.1.1 Communication	2% 17% 67% 14% 0%	76%	24%	14% 81% 5% 0% 0%	97%	3%	91% 5% 2% 2% 0%	97%	3%
1.2.1.2 Delegation 1.2.1.3 Recognition 1.2.1.4 Rewards 1.2.1.5 Employee Satisfaction & Morale 1.2.1.6 Employee & Labor Relations	**Comments:** *Lack of communication is the main cause of failure.* *- These issues are at the level of organizational systems and structures: Beyond the scope of the Bronze practitioner.* *- Awareness.* *- Improvement is usually the preview of supervision of management. Tactical implementation should understand concept but not on exam requirement.* *- Followers at this stage.* *- Awareness.* *- Important areas; no need for tough questions about them.* *- No communication no program.*			**Comments:** - *Required for fundamentals.*			**Comments:** - *Too operational and tactical to be at the strategic level.* *- Must be.* *- Emphasize in conjunction with questions on building a lean work culture.* *- Upper Management looking to go in the Lean direction should already have this in their knowledge base. Don't waste their time in reviewing things that they should already know.*		

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Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination? **I. ENABLERS FOR LEAN**	BRONZE (Tactical)			SILVER (Integrative)			GOLD (Strategic)		
	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important		Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important		Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important		Necessary for Certification exam?
1.2.2. Employee training and development	4 3 2☑ 1 0	Yes☑ No	4 3☑ 2 1 0	Yes☑ No	4☑ 3 2 1 0	Yes☑ No
1.2.2.1 Instructional Goals	5% 20% *58%* 15% 2%	70% 30%	12% *81%* 7% 0% 0%	98% 2%	86% 10% 2% 2% 0%	97% 3%
1.2.2.2 Skills Assessment 1.2.2.3 Continuous Learning Strategy 1.2.2.4 Cross-Training 1.2.2.5 Classroom and On-the-Job Training 1.2.2.6 Coaching & Mentoring	**Comments:** - *Not at this level.* - *Followers.* - *Fundamental needs.* - *1, 2, 4, & 5 are basic. Something missing is training or coaching to hold standard work.* - *Training is essential and fundamental to any lean effort*			**Comments:** - *Mentoring!* - *Coaching & mentoring.* - *All sub-points are important.* - *While important for all levels of Lean, I feel that the Integrative Level should have the highest competency level in categories 1.2.2 to 1.2.6 due to the nature of the Integrative level.*			**Comments:** - *Mentoring!* - *Too "in the trenches" for strategic level.* - *These may be one question to insure knowledge is secure.* - *Employ and develop.* - *Need to know how to develop the entire workforce.*		
1.2.3. Teamwork	4 3 2☑ 1 0	Yes☑ No	4☑ 3 2 1 0	Yes☑ No	4☑ 3 2 1 0	Yes☑ No
1.2.3.1 Cross-Functional Team Selection & Leadership	7% 39% *52%* 2% 0%	98% 2%	*88%* 10% 2% 0% 0%	100% 0%	*91%* 7% 2% 0% 0%	98% 2%
1.2.3.2 Multi-Level Participation 1.2.3.3 Roles & Responsibilities 1.2.3.4 Decision-Making Types 1.2.3.5 Team Dynamics (Storming, norming, etc.)	**Comments:** *Teamwork is key.* - *Team dynamics is fundamental to this level-needs to be mastered here.* - *Test on 1.2.3.1-.2-.3* - *Fundamental need.* - *Importance ramps up as the exam level rises.* - *Team selection is very much a tactical effort.* - *Test on familiarity with subject, provide general exposure.*			**Comments:** - *Test on 1.2.3.4_5* - *Fundamental need.* - *Importance ramps up as the exam level rises.*			**Comments:** - *Redundant if already covered in silver and gold.* - *Leader select of members.* - *Importance ramps up as the exam level rises.*		

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1.2.4. Suggestion/Feedback/ Appraisal System	4	3	2 ■	1	0	Yes ■	No	4	3 ■	2	1	0	Yes ■	No	4 ■	3	2	1	0	Yes ■	No
1.2.4.1 Information Sharing	3%	24%	61%	10%	0%	78%	22%	14%	76%	8%	2%	0%	98%	2%	90%	8%	2%	0%	0%	98%	2%

Comments: - Not a core requirement for a basic practitioner. - Not tactical, not for followers to know yet. - Not required. - Covers ops instruction and work discussion: basic stuff. - The more information is shared the better the chance of success and therefore this is definitely a tactical issue. - Not sure what is intended here, but all Lean participants should be exposed to and know the importance of a good system for feedback and suggestions to enhance communications.	Comments: - May conduct be part of. - More on knowledge management as a system.	Comments: - Must conduct. - How to inspire sharing of best methods among all parts of the company.

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Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination?	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?	
I. ENABLERS FOR LEAN	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
1.2.5. Employee Turnover, Absenteeism and Compensation				☑			☑ No			☑				☑ No	☑					☑ Yes	
	0%	5%	19%	66%	10%	9%	91%	2%	20%	70%	8%	0%	27%	73%	56%	39%	2%	3%	0%	93%	7%

Comments (Bronze): - Impact on sustain gains. - It should be important for ops level staff to understand how lean work design can contribute to these. - How to create an environment in which people want to come to work is more like it. - Absenteeism control is critical.

Comments (Silver): - As it relates to the cost to the business if TO is high. - At this level, job and systems design can create a good or a poor work environment. That can affect these results. - Often a "hidden" cost - accepted as a given. - Should understand impact. - Impact on sustain gains. - How to create a good work environment. Knowledge that metrics can discourage collaboration is important.

Comments (Gold): - Stability in this area is pre-requisite to lean. - While important overall, turnover, absenteeism, and compensation are competencies needed outside and addition to lean certification. - Must use lean to inspire workers to prevent turnover. - All three are important surrogate measures of "morale." Should know how to create a good work environment. - Any middle or upper management person who doesn't understand this concept hasn't earned their stripes.

	BRONZE							SILVER							GOLD						
	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
1.2.6. Ergonomic, clean and safe work environment, and results	☑					☑ Yes		☑					☑ Yes		☑					☑ Yes	
1.2.6.1 Environment	76%	17%	5%	2%	0%	95%	5%	91%	7%	2%	0%	0%	100%	0%	93%	3%	2%	2%	0%	98%	2%

1.2.6.2 Ergonomics
1.2.6.3 Safety

Comments (Bronze): - Why important only. - Relation to 5S. - Basics. - Critical element of 5S.

Comments (Silver): - How to achieve. - 5S integration. - Basics.

Comments (Gold): - These must be central issues at all levels of the business. Safety and care for people should not be fully delegated. - Add environment. - 5S integration. - Gold candidates should have most of this down in prior exams.

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Additional Areas from Pre-Delphi	BRONZE (Tactical)			SILVER (Integrative)			GOLD (Strategic)		

Motivation Theory

	4	3	2	1	0	Yes	No
BRONZE	5%	12%	57%	21%	5%	20%	80%
SILVER	10%	65%	25%	0%	0%	85%	15%
GOLD	75%	21%	4%	0%	0%	88%	12%

BRONZE Comments: - Even at the tactical level motivation theory is worth being on the exam.
- Must address the "what's in it for me?" mentality.
- Understanding what motivates people is key to implementing "lean".
- A follower at this level.
- How to maintain organization to focus change.
- We should have a understanding of what motivates workers to avoid a too mechanistic job design outcome.
- OK, but too much is in the exam already.

SILVER Comments: - Practical skill.
- Covered under empowerment.
- Must be able to inspire organization.
- Provide information which can be used as a tool, but don't need to be tested.

GOLD Comments: - Keep the B.S. at the top.
- Covered under empowerment.
- Leadership role.

Socio-technical Systems

	4	3	2	1	0	Yes	No
BRONZE	2%	4%	19%	67%	9%	7%	93%
SILVER	5%	51%	44%	0%	0%	69%	31%
GOLD	31%	52%	17%	0%	0%	78%	22%

(An approach to design work that involves the interaction between people & technology at workplace)

BRONZE Comments: - Must "match" skill level of employees to technology expected to use on job.
- A follower at this level.
- Interrelationships a minor concern.
- A work cell is a classic example of a case where STS should be considered. Ops-level staff contribute to this type of work environment.
- Already too much in the exams. A Brit antecedent of lean and cells. (Once had dinner with the originator, Sir John Burbidge.)

SILVER Comments: - Covered under empowerment.
- Ability to understand and influence.

GOLD Comments: - I interpret this as autonomation and appropriate use of automation, robotics, and technology such as IT, computers, bar coding, etc. This is beyond Bronze basics and probably most appropriate to the silver level.
- Covered under empowerment.
- Understanding of interpersonal skills.
- Too vague, it seems as if this is covered in other areas.

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Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination? **II. LEAN CORE OPERATIONS**	BRONZE (Tactical)				SILVER (Integrative)				GOLD (Strategic)			
	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important			Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important			Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important			Necessary for Certification exam?
2.1.1. Operational Vision and Strategy	4 3 **2** 1 0 (■ at 2)			Yes / **No** (■ No)	4 **3** 2 1 0 (■ at 3)			**Yes** / No (■ Yes)	**4** 3 2 1 0 (■ at 4)			**Yes** / No (■ Yes)
2.1.1.1 Operation Processes Vision, Mission, Strategy & Goals	0% 11% 72% 17% 0%			19% **81%**	10% 80% 10% 0% 0%			**98%** 2%	93% 5% 2% 0% 0%			**100%** 0%
2.1.1.2 Lean Principles in Strategy 2.1.1.3 Empowerment in Strategy 2.1.1.4 Operational Alignment with Organizational Vision, Mission, Strategy & Goals	Comments: - *How and why lean is practiced at the tactical level and how it links to organizational vision, etc. is important area to be on exam.* - *Alignment with 1.1.1 is critical.* - *Awareness and user of.* - *Know what this is.*				Comments: - *User and input.* - *Know how to execute.*				Comments: - *Critical!* - *Developer and owner.* - *Know how to formulate and deploy.* - *Test primarily at silver level.*			
2.2.1 Product Design and Development	4 3 **2** 1 0 (■ at 2)			Yes / **No** (■ No)	4 **3** 2 1 0 (■ at 3)			Yes / No (■ Yes)	**4** 3 2 1 0 (■ at 4)			**Yes** / No (■ Yes)
2.2.1.1 Quality Function Deployment	4% 10% 68% 18% 0%			33% **67%**	12% 79% 9% 0% 0%			**100%** 0%	86% 14% 0% 0% 0%			**100%** 0%
2.2.1.2 Concurrent Engineering 2.2.1.3 Variety Reduction 2.2.1.4 Engineering Changes 2.2.1.5 Design for Manufacture & Assembly 2.2.1.6 Design for Product Life Cycle (DFx) 2.2.1.7 Failure Mode & Effects Analysis (FMEA) 2.2.1.8 Life Cycle Engineering 2.2.1.9 Production Process Preparation (3P) 2.2.1.10 Knowledge Transfer Methods &	Comments: - *Important but outside the scope of lean.* - *Even if at a 50,000+ Level, knowledge of these tools should be known/be demonstrated via exam.* - *Critical in new product development but not necessarily at tactical level in operations.* - *People who do the work are the experts. They need to design improvement experiments for themselves and perform FMEA.* - *Quality is very important to Lean operations.* - *A follower at this level.* - *Limit to awareness.*				Comments: - *User of, but more six sigma than Lean.* - *They should be involved in all these from time to time.* - *Awareness that these tools exist is good, some familiarity of application is also useful, but mastery of these is not necessary for Lean success.*				Comments: - *User and may be process owner of a portion of.* - *Big emphasis here. For many companies, design is where the big lean payoff comes.* - *Awareness that these tools exist is good, some familiarity of application is also useful, but mastery of these is not necessary for Lean success.*			

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Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination?	BRONZE (Tactical)					Necessary for Certification exam?		SILVER (Integrative)					Necessary for Certification exam?		GOLD (Strategic)					Necessary for Certification exam?	
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important		
2.2.1 Product Design and Development	4	3	2 ■	1	0	Yes	*No* ■	4	3 ■	2	1	0	*Yes* ■	No	4 ■	3	2	1	0	*Yes* ■	No
2.2.1.1 Quality Function Deployment	4%	10%	68%	18%	0%	33%	67%	12%	79%	9%	0%	0%	100%	0%	86%	14%	0%	0%	0%	100%	0%

2.2.1.2 Concurrent Engineering
2.2.1.3 Variety Reduction
2.2.1.4 Engineering Changes
2.2.1.5 Design for Manufacture & Assembly
2.2.1.6 Design for Product Life Cycle (DFx)
2.2.1.7 Failure Mode & Effects Analysis (FMEA)
2.2.1.8 Life Cycle Engineering
2.2.1.9 Production Process Preparation (3P)
2.2.1.9 Production Process Preparation (3P)
2.2.1.10 Knowledge Transfer Methods & Practices

- Keep a question or two in the exam. in a lean environment, everyone gets into NPD to some extent.
- Vision is required at all levels for success.
- Awareness that these tools exist is good, but not needed at this level.

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	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Yes	No	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Yes	No	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Yes	No
2.2.2. Product Market Service	4	3	2	*1* ☑	0	Yes	*No* ☑	4	*3* ☑	2	1	0	*Yes* ☑	No	*4* ☑	3	2	1	0	*Yes* ☑	No
2.2.2.1 Customer Feedback & Market Needs Analysis	0%	2%	30%	57%	11%	7%	93%	4%	51%	45%	0%	0%	67%	33%	71%	27%	2%	0%	0%	96%	4%

2.2.2.2 Customer Specs and Requirements
2.2.2.3 New market development & current market exploitation
2.2.2.4 E-commerce systems
2.2.2.5 Benchmarking

Comments: - *Understanding of what drives the value stream- who defines waste. Certification at a higher level.*
- *Not important except for benchmarking.*
- *Emphasize mostly sub-points 2 and 5.*

Comments: - *Feedback and specs are important. Not necessary for certification though at the Silver level.*
- *Awareness of customer feedback and benchmarking.*
- *Some knowledge of all sub-points.*
- *Test primarily at gold level. Expose silver level to fundamentals, only.*

Comments: - *Outside the scope for lean.*
- *Critical to design of customer focused business strategy.*
- *For a general manager, emphasis sub-points 1 and 3. The rest they should "have down."*

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2.3.1. Suppliers	4 3 2 1 0	Yes No	4 3 2 1 0	Yes No	4 3 2 1 0	Yes No
2.3.1.1 Supplier Development Processes	0% 45% 45% 7% 3%	26% 74%	5% 86% 7% 2% 0%	97% 3%	88% 9% 3% 0% 0%	100% 0%
2.3.1.2 Supplier Certification 2.3.1.3 Supplier Benchmarking 2.3.1.4 Supplier Satisfaction Measures 2.3.1.5 Corrective Action System	**Comments:** - *Important to the extent it's part of the value chain.* - *This is purely integrative.* - *Several think this is focused on external suppliers, I think this is out of scope at this level.* - *Only needed if the tactical project is in this area.* - *Basic SQA.* - *It seems that we agree it is important but not enough to warrant a test question. I think questions should be related to ops-level work.* - *Another big payoff area, too little emphasized. Importance ramps up with the exam level.* - *You must control your own system before dealing with supplies.*		**Comments:** - *Impact on takt & cycle time.* - *Integration focus here.*		**Comments:** - *Developer and application.* - *Strategy focus here.*	
2.3.2 Customers	4 3 2 1 0	Yes No	4 3 2 1 0	Yes No	4 3 2 1 0	Yes No
2.3.2.1 Customer Training & Development Processes	0% 4% 32% 59% 5%	25% 75%	9% 70% 19% 2% 0%	93% 7%	88% 12% 0% 0% 0%	100% 0%
2.3.2.2 Customer Selection Focus 2.3.2.3 Demand Load Leveling 2.3.2.4 Corrective Action System	**Comments:** - *Important to the extent it's part of the value chain.* - *This level of involvement would occur at Silver and Gold levels.* - *More operations focus than lean, although 2.3.2.3 is critical to setting up lean production.* - *All employees have to be customer focused and CA aware!* - *Only why level load implementation, not how to achieve it.* - *Very little impact.* - *Importance ramps up with the exam level.* - *Demand load leveling is a key component of lean and needs to be considered at the tactical level.* - *Load leveling focus only.*		**Comments:** - *CAR only.* - *Test fundamentals here, but put more emphasis in gold level exam.* - *Awareness of the importance of these areas is good, but I don't think the Silver Lean expert needs to be the expert in these areas.*		**Comments:** - *User level except application of CAR.* - *Very important at the general manager level.*	

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Results of Round Two Delphi

Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination? **II. LEAN CORE OPERATIONS**	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	*Necessary for Certification exam?* Yes	No	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	*Necessary for Certification exam?* Yes	No	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	*Necessary for Certification exam?* Yes	No
2.3.3. Distribution & Transport Alliances	4	3	2 ■	1	0	Yes	*No* ■	4	*3* ■	2	1	0	*Yes* ■	No	*4* ■	3	2	1	0	*Yes* ■	No
2.3.3.1 Warehousing	0%	5%	*64*%	31%	0%	10%	*90*%	2%	74%	24%	0%	0%	*93*%	7%	73%	27%	0%	0%	0%	*100*%	0%

2.3.3.2 Distribution Centers

2.3.3.3 Cross-Docks

2.3.3.4 Reverse Logistics

2.3.3.5 Remanufacturing/ Maintenance, Repair and Overhaul (MRO)

2.3.3.6 Just-in-Time Alliances

2.3.3.7 Supplier Managed Inventory Systems

Comments (BRONZE): - *This is really dependent on the value stream in a particular business - everyone should understand basic concepts. Certification at higher level.*
- *Need understanding of JIT with regard to alliances.*
- *Everybody should know a little about sub-points 1, 2, 3, and 7.*

Comments (SILVER): - *Oversight knowledge only.*
- *Fundamentals only.*
- *Should know a little about all of this.*

Comments (GOLD): - *Complete understanding of impact on takt & cycle time.*
- *Should know how to form and use alliances, sub-point 6. Should have most of the rest down pat.*

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2.4.1. Systematic identification and elimination of waste	4 ▪ 3 ☐ 2 ☐ 1 ☐ 0 ☐	Yes ▪ No ☐	4 ▪ 3 ☐ 2 ☐ 1 ☐ 0 ☐	Yes ▪ No ☐	4 ▪ 3 ☐ 2 ☐ 1 ☐ 0 ☐	Yes ▪ No ☐
2.4.1.1 Waste Identification and elimination of waste	93% 7% 0% 0% 0%	100% 0%	95% 5% 0% 0% 0%	100% 0%	93% 3% 2% 2% 0%	93% 7%
2.4.1.2 Value Stream Mapping 2.4.1.3 Value Analysis 2.4.1.4 5S Standards & Discipline 2.4.1.5 Visual Workplace 2.4.1.6 Kaizen Blitz Events 2.4.1.7 Mistake Proofing 2.4.1.8 Source Inspection 2.4.1.9 Continuous Improvement 2.4.1.10 Five Why's Problem Solving	**Comments:** - *Prime person on the scene.* - *Core concepts.* - *Must be.* - *Big emphasis here.*		**Comments:** - *Must be.* - *Less emphasis here.*		**Comments:** - *Should have already proven competency in Silver & Bronze.* - *I don't see this as necessary on the strategic level - It's wasteful to cover this fundamental topic at the strategic level - It's nearly purely tactical.* - *No need to test this topic thrice.* - *Tested twice before.* - *Leader of initiative.* - *Should have already proven themselves on this points except for how to integrate practices in a specific situation.* - *Cover sufficiently in previous exam levels.*	

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Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination? II. LEAN CORE OPERATIONS	BRONZE (Tactical)			SILVER (Integrative)			GOLD (Strategic)		
	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important		Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important		Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important		Necessary for Certification exam?
2.4.2. Just-in-Time Operations	4 ■ 3 □ 2 □ 1 □ 0 □		*Yes* ■ No □	4 ■ 3 □ 2 □ 1 □ 0 □		*Yes* ■ No □	4 ■ 3 □ 2 □ 1 □ 0 □		*Yes* ■ No □
2.4.2.1 Takt Time	88% 12% 0% 0% 0%		**100** % 0%	97% 3% 0% 0% 0%		**100** % 0%	91% 7% 2% 0% 0%		**97** % 3%
2.4.2.2 Material Signals 2.4.2.3 Pull System 2.4.2.4 Continuous Flow 2.4.2.5 Just-in-Time (JIT) 2.4.2.6 Setup Reduction (SMED) 2.4.2.7 Total Productive Maintenance (TPM) 2.4.2.8 Load-Leveling (Heijunka)	**Comments:** *- These are the tools you will use.* *- Core concepts.* *- (Basic need) Must be.* *- Technique basics.*			**Comments:** *- Basic principles of!!* *- Basics, all. More emphasis on sub-points 7 and 8.*			**Comments:** *- Should have already proven competency in Silver & Bronze.* *- No need to test this topic thrice.* *- Tested twice before.* *- Implementation and evaluation of.* *- Should have most of this down by now.* *- Cover sufficiently in previous exam levels.*		
2.4.3. Cellular & Continuous Flow	4 ■ 3 □ 2 □ 1 □ 0 □		*Yes* ■ No □	4 ■ 3 □ 2 □ 1 □ 0 □		*Yes* ■ No □	4 ■ 3 □ 2 □ 1 □ 0 □		*Yes* ■ No □
2.4.3.1 Cellular Manufacturing	89% 11% 0% 0% 0%		**100** % 0%	97% 3% 0% 0% 0%		**100** % 0%	86% 10% 0% 2% 2%		**91** % 9%
2.4.3.2 One Piece Flow 2.4.3.3 Standard Work 2.4.3.4 Multi-process Handling 2.4.3.5 Autonomation 2.4.3.6 Production Schedule 2.4.3.7 Bills of Materials 2.4.3.8 Routings 2.4.3.9 Flow Analysis Charts	**Comments:** *- BOM and routings do not need included for "lean certification". It's important but more applicable to APICS certification.* *- Core concepts.* *- Fundamentals of lean.* *- Technique basics.* *- 2431/2/3 only at this level.*			**Comments:** *- Fundamentals are essential.* *- Less emphasis here.*			**Comments:** *- Should have already proven competency in Silver & Bronze.* *- Not strategic in nature.* *- No need to test this topic thrice.* *- Tested twice before.* *- Implementation and evaluation of.* *- Should have most of this down by now.* *- Cover sufficiently in previous exam levels.*		

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Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination? **II. LEAN CORE OPERATIONS**	BRONZE (Tactical)						GOLD (Strategic)					
	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important		Necessary for Certification exam?		Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important		Necessary for Certification exam?		Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important		Necessary for Certification exam?	
2.4.4. Lean Tools for Continuous Improvement	4 ■ 3 □ 2 □ 1 □ 0 □		Yes ■ No □		4 ■ 3 □ 2 □ 1 □ 0 □		Yes ■ No □		4 ■ 3 □ 2 □ 1 □ 0 □		Yes ■ No □	
2.4.4.1 Plan-Do-Check-Act	91% 7% 2% 0% 0%		100% 0%		96% 4% 0% 0% 0%		100% 0%		89% 7% 2% 0% 2%		91% 9%	
2.4.4.2 Reliability & maintainability	**Comments:** - *Core concepts.* - *Awareness to the level of interpreting and participation in.* - *Basic techniques. PDCA and root cause applies at any level.* - *Familiarity of these critical tools.*				**Comments:** - *Leader implementation creator application of.* - *A little less emphasis on technique here.* - *Primary testing of these should be at bronze level.* - *Ability to use these tools.*				**Comments:** - *Should have already proven competency in Silver & Bronze.* - *Not strategic in nature.* - *Already covered.* - *No need to test these topics thrice.* - *Tested twice before.* - *Leader implement creator. application of.* - *Very important and fundamental, but assume that they know this stuff.* - *Mastery and knowledge of when and where to use which tool.*			
2.4.4.3 Root Cause & Corrective Action												
2.4.4.4 Flow Charting												
2.4.4.5 Pareto												
2.4.4.6 Cause & effect Diagrams												
2.4.4.7 Check Sheets												
2.4.4.8 Histograms												
2.4.4.9 Scatter & Concentration Diagrams												
2.4.4.10 Control Charts												
2.4.4.11 Problem Solving Storyboards												

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Additional Areas from Pre-Delphi	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
	4	3	**2**	1	0	Yes	**No**	4	**3**	2	1	0	**Yes**	No	**4**	3	2	1	0	**Yes**	No
Six Sigma/Problem Solving Techniques	☐	☐	■	☐	☐	☐	■	☐	■	☐	☐	☐	■	☐	■	☐	☐	☐	☐	■	☐
	9%	8%	59%	19%	5%	29%	71%	16%	55%	22%	4%	3%	79%	21%	55%	31%	9%	2%	3%	86%	14%

	BRONZE (Tactical)	SILVER (Integrative)	GOLD (Strategic)
	Comments: - Five Why's, Gemba, but not six sigma. - Need to understand concept of six sigma - not necessarily formal methodology. - Need lean basics in place first. - Limit to awareness. - It would be nice to have an understanding of the upsides/downsides to SS, but it probably is not in the spirit of this exam. - Enough crossover to check with a question or two. - Most of this is the same as the above items (Problem Solving, control charts, pareto, etc. Redundant - Familiarity only. This is not Six Sigma certification and it takes away from emphasis. - No six sigma - Wrong message.	**Comments:** - Oversight & alignment knowledge only. - Awareness only. - Should be aware. At this level- of distinction between lean and six sigma to select appropriate tools. - Basic understanding. - Check for DMAIC or whatever; do they know a range of material. - Familiarity only. This is not Six Sigma certification and it takes away from Lean emphasis.	**Comments:** - Awareness only. - Not strategic in nature. - Should six sigma be kept separate? - Necessary to design strategic lean + six sigma program. - Comprehension of techniques. - Assume that they know this stuff. - Familiarity only. This is not Six Sigma certification and it takes away from Lean emphasis.

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Quantitative Decision Making Techniques	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
	☐	☐	■	☐	☐	☐	■	☐	■	☐	☐	☐	■	☐	■	☐	☐	☐	☐	■	☐
	6%	11%	58%	16%	9%	29%	71%	15%	54%	25%	0%	6%	80%	20%	61%	27%	4%	2%	6%	85%	15%

Comments: - Need more specifics. Six sigma, simulation, optimization are all quantitative in nature.	Comments: - Oversight knowledge only.	Comments: - Oversight knowledge only.
- Data is critical.	- No references in body of knowledge - Out of Lean scope.	- Not in BOK.
- Probably the most useful measure. Probably translates to $$.	- Participation and user.	- Load and interpret.
- Need lean basics in place first.	- Good topical area but will be should be covered elsewhere.	- Good topical area but will be should be covered elsewhere.
- Participation in developer.	- Knowledge that there are additional tools which they can use to make decisions is useful, but don't need to make them a master of all of them.	
- Too much stuff already.		
- Good topical area but will be should be covered elsewhere.		
- Most of this is the same as the above items (Problem Solving, control charts, pareto, etc. Redundant		
- Can become over emphasized. Better to do than analyze.		

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II. Additional Areas from Pre-Delphi	BRONZE (Tactical)		SILVER (Integrative)		GOLD (Strategic)	
	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?
Simulation Technique	4 3 2 *1* 0	Yes *No*	4 *3* 2 1 0	*Yes* No	4 *3* 2 1 0	*Yes* No
	☐ ☐ ☐ ■ ☐	☐ ■	☐ ■ ☐ ☐ ☐	■ ☐	☐ ■ ☐ ☐ ☐	■ ☐
	2% 3% 23% *62%* 10%	14% *86%*	3% *47%* 37% 10% 3%	*59%* 41%	14% *59%* 22% 2% 3%	*71%* 29%
	Comments: - Simulation and training bring home tactile understanding of participants. - Needed to assist in training/testing. - Principles of. - Simulation is used so much that they should know what it is. Check for knowledge of computer model simulation versus mock-up simulation, as with 3P. - Simulation technique is not a lean/TPS tool specifically. - Not critical or necessary. Purely an option.		**Comments:** - Oversight knowledge only. - Bring in an expert or specialist as needed. - Not necessary as many companies don't use this. - Limited practical application. - Valuable but not essential. - Principles of. - Simulation is used so much that they should know what it is. Check for knowledge of computer model simulation versus mock-up simulation, as with 3P. - Simulation technique is not a lean/TPS tool specifically.		**Comments:** - Oversight knowledge only. - Important to business decision-making, but not part of the lean body of knowledge. - Not necessary as many companies don't use this. - Understand when it may be of value. - Simulation is used so much that they should know what it is. Check for knowledge of computer model simulation versus mock-up simulation, as with 3P. - This is very specific expertise that should not necessary for Lean certification. Awareness that simulation is a powerful tool, which may be useful is good, but mastery of the tool is unnecessary.	

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Optimization Techniques	4 3 2 *1* 0 Yes *No*	4 3 2 1 0 Yes *No*	4 *3* 2 1 0 *Yes* No
	0% 5% 24% *62%* 9% 7% *93%*	5% 21% *60%* 12% 2% 49% *51%*	22% *59%* 14% 3% 2% *78%* 22%
	Comments: - Basics of perfection. - Too much stuff already. - Optimization techniques are not lean/TPS tools specifically. They are Industrial Engineering/Operations Research tools.	**Comments:** - Oversight knowledge only. - Important to business decision-making, but not part of the lean body of knowledge. - This should be covered in flow. - Application to drive perfection. - Optimization techniques are not lean/TPS tools specifically. They are Industrial Engineering/Operations Research tools.	**Comments:** - Oversight knowledge only. - Important to business decision-making, but not part of the lean body of knowledge. - This should be already covered in flow. - Driver for perfection. - Optimization techniques are not lean/TPS tools specifically. They are Industrial Engineering/Operations Research tools. - This is very specific expertise that should not necessary for Lean certification. Awareness that optimization is a powerful tool, which may be useful is good, but mastery of the tool is unnecessary. - Same as simulation. Not a necessity.
Facilities Design and Layout	4 3 *2* 1 0 Yes *No*	4 3 2 1 0 *Yes* No	*4* 3 2 1 0 *Yes* No
	3% 17% *61%* 17% 2% 36% *64%*	20% *64%* 12% 2% 2% *86%* 14%	*64%* 30% 2% 2% 2% *97%* 3%
	Comments: - If facilities are not optimized you must improvise. - Bronze practitioner will be faced this on day one! - Too technical, would request this from a facility engineer. - Can't do lean without this. - Impact on flow. - I believe this is a critical need. I guess it depends on if the layout work is on the macro, micro, or submicro levels. - Should at least understand the reasons for flexible design of facilities. - In terms of flow support.	**Comments:** - Practical experience. - Understanding yes, but not necessary at a technical level. - Analyze impact on flow -- takt time. - How to lay out a lean operation.	**Comments:** Oversight knowledge only. - This is where it counts. - Understand, but not necessary at a technical level. - Analyze impact on flow -- takt time. - How to lead people in design or re-design of a facility. - Seems most appropriate to test at integration level (silver).

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III. BUSINESS CORE OPERATIONS-SUPPORT FUNCTIONS	BRONZE (Tactical)		SILVER (Integrative)		GOLD (Strategic)	
	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?
3.1.1 Administrative Vision & Strategy	4 3 **2** 1 0 ☐ ☐ ■ ☐ ☐	*Yes* ■ No ☐	4 **3** 2 1 0 ☐ ■ ☐ ☐ ☐	*Yes* ■ No ☐	**4** 3 2 1 0 ■ ☐ ☐ ☐ ☐	*Yes* ■ No ☐
3.1.1.1 Application of Lean principles & techniques	2% 18% *75%* 5% 0%	*81* % 19%	17% *80* % 3% 0% 0%	*98* % 2%	*91%* 9% 0% 0% 0%	*100* % 0%
3.1.1.2 Focus on value adds & waste identification & elimination 3.1.1.3 Commitment to Continuous Improvement 3.1.1.4 Business operations improvement metrics	**Comments:** - *Lean needs to go beyond the shop floor.* - *Few truly understand the concept of continuous learning and improvement. Most turn every opportunity into a major project. Critical culture shift required.* - *Should rate ~ 1.1.4* - *Awareness and comprehension of.* - *Important, but except for sub-point 4, very hard to evaluate in a written test.* - *Vision & Strategy should be tested at higher levels (silver & gold).* - *Only form the perspective that Lean is equally applicable to administrative processes.*		**Comments:** - *Key to value stream optimization.* - *Demonstrate knowledge & comprehension.* - *Important, but except for sub-point 4, very hard to evaluate in a written test.*		**Comments:** - *Driver and leader -- application.* - *Important, but except for sub-point 4, very hard to evaluate in a written test.*	

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III. BUSINESS CORE OPERATIONS-SUPPORT FUNCTIONS	BRONZE (Tactical)		SILVER (Integrative)		GOLD (Strategic)	
	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?
3.1.2. Alignment & Systematic Business & Service Process Design	4 3 **2** 1 0	Yes **No**	4 **3** 2 1 0	**Yes** No	**4** 3 2 1 0	**Yes** No
3.1.2.1 Finance & Accounting: Measurement & control systems, etc	0% 7% *69*% 22% 2%	19% *81*%	12% *76*% 10% 2% 0%	*93*% 7%	*88*% 10% 0% 2% 0%	*98*% 2%
3.1.2.2 Human Resources: Alignment of selection, development, teamwork, performance feedback & discipline, compensation & rewards, etc. 3.1.2.3 Materials Management:Inventory Control,planning&scheduling,logistics, etc 3.1.2.4 Information Technology:Appropriate alignment with process changes, accessibility,etc 3.1.2.5 Sales&Marketing:Alignment of sales&operations planning&execution,etc 3.1.2.6 Quality Assurance: Regulation & certification, inspection rationale, etc 3.2.1.7 Process & Manufacturing Engineering: System for engineering changes, concurrent 3.2.1.8 Legal & Regulatory: Alignment with core lean thinking, etc	**Comments:** *- 3.1.2.1 - No; 3.1.2.2- No; 3.1.2.3 - Yes; 3.1.2.4 - Very Important; 3.1.2.5 - No; 3.1.2.6 - Yes; 3.1.2.7 - Very Important; 3.1.2.8 - No - Awareness perhaps, but do not need to master. - Limited to awareness. - This area probably is warranted for testing if we expect Bronze holders to offer/sell their qualifications to work in these domains. - Alignment is at a higher lever than Bronze. - Need at least communication and basic understanding or these come obstacles.*		**Comments:** *- Awareness but do not need to master. - Administrative waste is the biggest opportunity to improve most businesses. - Overlaps with other box but it is at a user level. - Easiest questions to write would check whether candidates recognize practices that are not consistent with lean. - Only form the perspective that Lean is equally applicable to these processes.*		**Comments:** *- 3.1.2.1 - Yes; 3.1.2.2- Yes; 3.1.2.3 - No; 3.1.2.4 - Very Important; 3.1.2.5 - Yes; 3.1.2.6 - No; 3.1.2.7 - Very Important; 3.1.2.8 - Yes - Awareness but do not need to master. - A must to be a leadership position especially for accountability. - Easiest questions o write would check whether candidates recognize practices that are not consistent with lean. - Test these topics primarily at strategic level.*	
Supply Chain Logistics	4 3 **2** 1 0	Yes **No**	4 **3** 2 1 0	**Yes** No	**4** 3 2 1 0	**Yes** No
	0% 6% *65*% 29% 0%	14% *86*%	8% *70*% 22% 0% 0%	*90*% 10%	*75*% 19% 6% 0% 0%	*98*% 2%
	Comments: *- Need basic understanding how supply chain affects operations. - Same as supplier. - Basic. Everyone should know things like milk run delivery, super markets, supplier managed inventory, etc.*		**Comments:** *- Awareness but do not need to master. - Fundamentals. - Need an understanding of logistics and the crucial effects of supplier performance on internal operations. - Familiarity only.*		**Comments:** *- Understanding logistics cost is critical to knowing total landed cost and developing a cost-effective lean supply chain strategy. - Fundamentals. - They should know this already. - A critical strategic item.*	

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Lean Accounting

	4	3	2	1	0	Yes	No
Column 1	2%	3%	22%	68%	5%	7%	93%
Column 2	3%	54%	39%	4%	0%	78%	22%
Column 3	71%	25%	0%	4%	0%	97%	3%

Column 1 Comments: - Same as 3.1.2.1?
- Lean accounting is starting to become the heading covering finance & accounting effects on lean. Also broadening into performance metrics in general.

Column 2 Comments: - Covered in APICS & CERM.
- I have not seen it ever used!
- Critical knowledge for arguing against traditional mass production thinking.
- Awareness only.
- Impact on organization.
- Really need to understand cost measurement implications at this level.

Column 3 Comments: - Awareness only.
- Impact on organization.
- At this level, candidates must be able to deal with the financial & accounting mis-matches with lean. Should know the basic problems very well.

Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)

	4	3	2	1	0	Yes	No
Column 1	4%	2%	60%	31%	3%	14%	86%
Column 2	7%	31%	55%	3%	4%	71%	29%
Column 3	51%	35%	7%	2%	5%	88%	12%

Column 1 Comments: - MRP is the opposite of a pull system.
- Not necessary.
- Awareness.
- An understanding would be nice but maybe this should be left to APICS certification.
- Need to know what these are (definitions), and how they do and don't interfaces with lean.
- Need to understand the proper usage of ERP in a lean context and the negative effects of MRP scheduling to forecast.

Column 2 Comments: - Covered in APICS & CERM.
- Practitioners must understand how to design the interface and linkages between MRP and Kanban systems. The two must work together.
- Not necessary.
- Depends on business.
- User
- Very important to know how to deal with IT aids and barriers to lean.
- Only as it supports or interfaces with the Lean effort.

Column 3 Comments: - Covered in APICS & CERM.
- Not necessary.
- User/Analysis of data.
- Very important to know how to deal with IT aids and barriers to lean.
- A critical strategic item.
- Only as it supports or interfaces with the Lean effort.

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Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination? **IV. QUALITY, COST & DELIVERY MEASURES**	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	\multicolumn Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?	
4.1.1 Quality Results	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
	■	□	□	□	□	■	□	■	□	□	□	□	■	□	■	□	□	□	□	■	□

	BRONZE							SILVER							GOLD						
4.1.1.1 Rework	79%	19%	2%	0%	0%	97%	3%	85%	12%	3%	0%	0%	100%	0%	97%	3%	0%	0%	0%	97%	3%

4.1.1.2 Customer PPM Rejects

4.1.1.3 First Pass Yield

4.1.1.4 Scrap

4.1.1.5 Process Variation

4.1.1.6 Cost of Quality

4.1.1.7 Warranty Costs

Comments (BRONZE): - Not that it is not important, but there must be some limit focus. Is tactical implementation.
- Need the tools.
- These are the process performance measures by which the results of lean implementation are ultimately measured. Their inclusion is a "must".
- Core concepts.
- Muda. Awareness.
- Basic definitions should be tested.
- Test fundamental knowledge and how to use to make improvement.

Comments (SILVER): - Identification - elimination of muda.
- One or two re-check questions will do.
- Test use at value stream level for decision making.

Comments (GOLD): - Tested twice before.
- Facilitate process of identification and elimination.
- They should have already been through this.
- Cover sufficiently in previous exam levels.

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4.2.1 Cost & Productivity Results	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
	■	□	□	□	□	■	□	■	□	□	□	□	■	□	■	□	□	□	□	■	□
4.2.1.1 Inventory Turns	84% 14% 2% 0% 0%					98%	2%	95% 5% 0% 0% 0%					100%	0%	96% 2% 2% 0% 0%					98%	2%

4.2.1 Cost & Productivity Results	Comments:	Comments:	Comments:
4.2.1.1 Inventory Turns 4.2.1.2 Record Accuracy 4.2.1.3 Cycle Time, Takt Time and Throughput Time 4.2.1.4 Operational Equipment Effectiveness (OEE) 4.2.1.5 Labor Value-Add 4.2.1.6 Product Cost Reduction 4.2.1.7 Changeover 4.2.1.8 Resource Utilization 4.2.1.9 Energy Efficiency 4.2.1.10 Performance to Load Leveling	- *These are fundamental concepts of business process performance measurement. Their understanding should be mandatory for every flavor of process improvement professional.* - *Core concepts.* - *Awareness and identification of impact on organization.* - *Basic definitions should be tested. Is 4.2.1.5, Labor Value Add redundant with Value Added, or does is refer to the labor cost roll-up by conventional cost accounting.* - *Test fundamental knowledge and how to use to make improvement.* - *Very broad and not all needs to be tested. Recommend only tested area for Bronze is 4213.*	- *Value stream metrics.* - *Awareness and understanding of impact on organization.* - *Should know how these fit together and reinforce each other.* - *Test use at value stream level for decision making.*	- *Redundant to cover at all levels.* - *Basic metrics. Enterprise, advanced metrics.* - *Ability to calculate and to be appropriate action of.* - *Should be thoroughly tested at Silver level. Recheck knowledge of integration.* - *Cover sufficiently in previous exam levels.*

SME/AME/SHINGO LEAN CERTIFICATION ROLE DELINEATION STUDY
Results of Round Two Delphi

Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination?	BRONZE (Tactical)				SILVER (Integrative)				GOLD (Strategic)			
	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important			Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important			Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important			Necessary for Certification exam?
IV. QUALITY, COST & DELIVERY MEASURES												
4.3.1 Delivery and Customer Service Measurement	4 ☐	**3** ☑	2 ☐ 1 ☐ 0 ☐	**Yes** ☑ No ☐	**4** ☑	3 ☐	2 ☐ 1 ☐ 0 ☐	**Yes** ☑ No ☐	**4** ☑	3 ☐	2 ☐ 1 ☐ 0 ☐	**Yes** ☑ No ☐
4.3.1.1 Line-Items Delivered On-Time to Customer Requirement	14% 56% 22% 8% 0%			78% 22%	69% 29% 2% 0% 0%			98% 2%	92% 5% 3% 0% 0%			95% 5%
4.3.1.2 Complete Orders Delivered On-Time to Customer Requirements 4.3.1.4 Premium Freight 4.3.1.5 Mistakes in Shipment 4.3.1.6 Warranty Response, Service, etc.	**Comments:** - Beyond the scope of nearly all point kaizens executed by a journeyman lean practitioner. - Core concepts, but may be not as emphatic in all industries. - Unless tactical project in this specific area. - Basics of impact on muda. - These refer to performance measurement. Should know definitions. - Test fundamental knowledge and how to use to make improvement. - Familiarity only.				**Comments:** - These metrics sit at the customer/supplier interfaces. Silver level practitioners are likely to have to work with these. - Basics of impact on muda with identification of. - These refer to performance measurement. Should know how to respond to poor performance. - Test use at value stream level for decision making.				**Comments:** - Too operational for strategic level. - User of the principles of muda and identification of waste. - Should understand the implications of what is measured and its implications. - Cover sufficiently in previous exam levels.			

SME/AME/SHINGO LEAN CERTIFICATION ROLE DELINEATION STUDY 27
Results of Round Two Delphi

Additional Areas from Pre-Delphi	BRONZE (Tactical)	SILVER (Integrative)	GOLD (Strategic)
International Organization for Standardization (ISO) and Lean	4 3 *2* 1 0 Yes *No* 4% 10% 49% 32% 5% 12% 88%	4 3 *2* 1 0 *Yes* No 3% 29% 61% 5% 2% 61% 39%	*4* 3 2 1 0 *Yes* No 49% 30% 17% 2% 2% 86% 14%
	Comments: - Limited to awareness. - Need to know what ISO is, not only for 9000 series, but 14000, and other, and how ISO certifications may counter or reinforce lean. - Unimportant to satisfy a marketing program. Results will speak for themselves.	**Comments:** - Not necessary. - Awareness and ability to browse. - Need to know what ISO is, not only for 9000 series, but 14000, and other, and how ISO certifications may counter or reinforce lean. - Should learn about the relationship, but not be tested on it.	**Comments:** - Not necessary. - More of a management decision on how to do you business. - ISO is only the formalization of what is already happening at a lean facility. - Only why strategically important- not how to achieve. - Awareness and ability to browse. - Need to know what ISO is, not only for 9000 series, but 14000, and other, and how ISO certifications may counter or reinforce lean.
Quality Management System (QMS)	4 3 *2* 1 0 Yes *No* 3% 7% 68% 17% 5% 22% 78%	4 *3* 2 1 0 *Yes* No 5% 52% 36% 2% 5% 69% 31%	*4* 3 2 1 0 *Yes* No 58% 30% 17% 0% 5% 83% 17%
	Comments: - N/A - We have basic quality covered elsewhere. - Ops-level people should have a background in quality, and understand how their contributions impact quality. - QMS and a lean system should be symbiotic. Should check knowledge of this. - Should already be incorporated into content of previous sections.	**Comments:** - Too broad a topic for inclusion. - N/A - QMS and a lean system should be symbiotic. Should check knowledge of this. - Should already be incorporated into content of previous sections.	**Comments:** - Too broad and nebulous and topic to be tested. - N/A - Goes hand in hand with ISO. - Small re-check. Should know this already. - Should already be incorporated into content of previous sections.

SME/AME/SHINGO LEAN CERTIFICATION ROLE DELINEATION STUDY
Results of Round Two Delphi

Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination?	BRONZE (Tactical)		SILVER (Integrative)		GOLD (Strategic)	
	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important	Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important	Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important	Necessary for Certification exam?
5.1.1 Customer Satisfaction Results	4 3 **2** 1 0 — [☑ at 2]	Yes **No** [☑ No]	4 **3** 2 1 0 — [☑ at 3]	**Yes** No [☑ Yes]	**4** 3 2 1 0 — [☑ at 4]	**Yes** No [☑ Yes]
5.1.1.1 Market Share 5.1.1.2 Reorder Rate 5.1.1.3 Customer Survey Results 5.1.1.4 Customer Audit Results 5.1.1.5 Other Customer Feedback 5.1.1.6 Value/Improvement Analysis 5.1.1.7 Customer Retention 5.1.1.8 Customer Awards	2% 5% *66%* 25% 2%	16% *84* %	3% *75%* 22% 0% 0%	*91%* 9%	*81%* 17% 2% 0% 0%	*97%* 3%
	Comments: - *Not necessary for lean.* - *Important concepts in running a business operation - peripheral to lean.* - *Value improvement is the main component.* - *Should know definitions and their importance to performance.* - *Didn't we already cover this before as well?*		**Comments:** - *Not necessary.* - *Value #1 the others are nice to know at an awareness.*		**Comments:** - *Not necessary.* - *Understanding of principles to take action.*	
5.2.1. Profitability Measurement	4 3 2 *1* 0 — [☑ at 1]	Yes **No** [☑ No]	4 **3** 2 1 0 — [☑ at 3]	**Yes** No [☑ Yes]	**4** 3 2 1 0 — [☑ at 4]	**Yes** No [☑ Yes]
5.2.1.1 Operating Income on Sales & Assets 5.2.1.2 Operating Income on Space 5.2.1.3 Fixed & Variable Costs 5.2.1.4 Cash Flow 5.2.1.5 Value Stream Profitability	5% 2% 24% *63* % 6%	15% *85* %	5% *63%* 27% 3% 2%	*88%* 12%	*81%* 17% 0% 0% 2%	*98%* 2%
	Comments: - *Minimum value at this level.* - *Fold into Lean Accounting. This is where that subject begins.* - *Already covered this before.*		**Comments:** - *ROI decision made at this level.* - *Needs to be knowledgeable of impact.* - *Fold into Lean Accounting. This is where that subject begins.*		**Comments:** - *Knowledge and interpretation.* - *Fold into Lean Accounting. This is where that subject begins.*	

SME/AME/SHINGO LEAN CERTIFICATION ROLE DELINEATION STUDY 29
Results of Round Two Delphi

Additional Areas from Pre-Delphi	BRONZE (Tactical)		SILVER (Integrative)		GOLD (Strategic)	
Lean Business Metrics	4 3 **2** 1 0 — ☐ ☐ ■ ☐ ☐	Yes _No_ — ☐ ■	4 **3** 2 1 0 — ☐ ■ ☐ ☐ ☐	_Yes_ No — ■ ☐	**4** 3 2 1 0 — ■ ☐ ☐ ☐ ☐	_Yes_ No — ■ ☐
	7% 10% 70% 8% 5%	44% 56%	14% 78% 7% 0% 1%	95% 5%	90% 8% 0% 0% 2%	97% 3%
	Comments: - _How to use metrics to express business performance important "the critical few."_ - _We cover metrics in multiple places already._ - _Must have awareness of how the organization is measured._ - _This too can be folded into Lean Accounting. This is where it is headed._ - _Already covered in previous sections._ - _You need to make the whole business lean and everyone can contribute._		**Comments:** - _Understand and react to!_ - _Fold into Lean Accounting. This is where that subject is headed._ - _Already covered in previous sections._		**Comments:** - _Should be included in Lean Accounting perhaps?_ - _Develop and understand._ - _Fold into Lean Accounting. This is where that subject is headed._ - _Already covered in previous sections._	
Total Supply Chain Cost	4 3 2 **1** 0 — ☐ ☐ ☐ ■ ☐	Yes _No_ — ☐ ■	4 **3** 2 1 0 — ☐ ■ ☐ ☐ ☐	_Yes_ No — ■ ☐	**4** 3 2 1 0 — ■ ☐ ☐ ☐ ☐	_Yes_ No — ■ ☐
	5% 0% 22% 66% 7%	9% 91%	5% 66% 24% 5% 0%	80% 20%	81% 15% 2% 2% 0%	98% 2%
	Comments: - _We cover suppliers elsewhere._ - _No value._ - _This too can be folded into Lean Accounting. It's part of that material._		**Comments:** - _Cheapest is not always best value._ - _Very little value._ - _This too can be folded into Lean Accounting. It's part of that material._		**Comments:** - _Awareness of._ - _This too can be folded into Lean Accounting. It's part of that material._	

SME/AME/SHINGO LEAN CERTIFICATION ROLE DELINEATION STUDY
Results of Round Two Delphi

Additional Comments if Any:

- The focus needs to be Lean and what it takes to be successful - Probably with more emphasis on implementation than tools, especially at Silver and Gold levels.
- It is overproduction (waste) to include the same topics at each level unless the topics are tailored to each level.
- Gold & Silver seem redundant - merge into one - this seems supported by the responses. Bronze needs to know a lot even if "tested" on major implication skills/application specifics.
- Some of the areas go beyond what can be practically certified. What is necessary or value-added to be Lean certified at the Bronze, Silver and Gold versus the nice-to-have.
- Good work. Keep it up.
- This is far too complex, and the structure of the survey almost forces the Gold level to be impossible to attain. If Bronze is the hands-on, floor-level lean champion, then all that should be required is the fundamental lean concepts, 2.4.1 and 2.4.2 Silver requirements should be centered on linking the continuous improvement opportunities to corporate strategy/planning. Honestly, I can't understand why anybody other than consultant, would even consider Gold. Anyone who understands and employs all of the competencies included is already running a successful business and has no need or interest in Lean certification. If this continues as is, and each level's exam covers all of this material, I believe this will be just one more example of how out of touch academia with industry. The idea of a certification is very good, but this is just too broad.
- It seems as though we are trending towards a low entry barrier for Bronze; our expectations for the Bronze certification does not seem in proportion to the other levels. This may not be a bad thing if we are looking to gain wide acceptance. I am concerned that doing so will jeopardize the credibility of the certification by making it too easy. For example, refer to the PMI Professional Project Manager. There are thousands of people getting PMP certification, and many have never managed a project. Thus, I see no value in the PMP certification since the large number of PMPs may suggest a test that is not rigorous enough.
- I think that most financial and accounting items can now be covered under a heading called lean accounting. Material on it is becoming more available. The cost accountants are finally beginning to take notice, too. The heading might not be called "Lean Accounting," however, but simply performance measurement. Doing so I think might make question writing on some of the rest of the exam easier. Dysfunctional or obsolete performance measures are a continuing impediment to lean, so this is very important.   Also in the present format it is difficult to indicate that the nature of questions on the same topics should be different at the different levels. Take this framework and break it into different levels, considering what should already be known to pass exams at the prior levels. That avoids redundancy when a limited number of questions can be prepped and taken at each level. More basic definition at the Bronze Level; operational integration at the Silver Level; and business or total enterprise integration at the Gold Level.   Another deficiency is that the human side of lean is still not fully recognized in the test. That becomes more important with advancing levels. It is becoming well-known that "Respect for People" and cultural change is vital to making lean an organizational way of life in which the techniques are embedded. It is not the way lean is now practiced in most organizations, but especially at the Gold Level, candidates should be aware of this.
- Under 'Respect for Humanity' the positive impact of Lean must be effectively communicated to internal employees. There is a belief out there (by a few people) that 'Lean' means job loss - this belief must be changed and is an important point under this category for the Bronze level.
- I look at the 3 levels as building on each other, especially given that one has to take each exam in order before proceeding forward. Given that prerequisite, I don't think the Gold exam for example, should test every area--it would be painfully long. It should only have a sampling of questions from the preceding exams and fill in with the new strategic areas that are only applicable to Gold. The other option would be to make the exams comprehensive for their levels, and not make them with prerequisites. Even though I think the structure and information provided to help people take the different exams are worthwhile, I am not sure if there will be a driving need for me to take the exams. Even though I essentially function at the Gold level in my organization, there would be quite a time and cost involvement in preparing for and taking the exams. I am not sure what the benefit to my organization would be for me to take the Bronze, then the Silver and finally the Gold exams . Clearly the knowledge gained would be useful, but I am already working on that on my own.

Thank you for your time and effort!

SME/AME/SHINGO LEAN CERTIFICATION ROLE DELINEATION STUDY
ROUND THREE DELPHI

<u>Directions</u>:

(1) Please look at the example below before completing the questionnaire. To complete the questionnaire, input your responses to each competency area by *check marking the box* which represents the rating you choose. **Please explain your choice** if it is two or more rating categories away from the modal (**in bold**) score. You may give any additional or general comments on the study in the space entitled "**Additional Comments**".

(2) Please email me back your completed questionnaire at: hiral.shah@emich.edu

EXAMPLE:

Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination? **I. ENABLERS FOR LEAN**	BRONZE (Tactical)					Necessary for Certification exam?		SILVER (Integrative)					Necessary for Certification exam?		GOLD (Strategic)					Necessary for Certification exam?	
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important		
1.1.1 Virtual Teams	4	3	2	1	0	Yes	*No*	4	3	2	1	0	*Yes*	No	*4*	3	2	1	0	*Yes*	No
	☐	☐	☐	☐	☑	☐	☑	☐	☑	☐	☐	☐	☑	☐	☑	☐	☐	☐	☐	☑	☐
	11%	19%	**36%**	26%	8%	46%	**54%**	20%	25%	25%	**30%**	0%	15%	**85%**	0%	7%	2%	1%	**90%**	2%	**98%**
	Comments: Knowledge of Virtual teams is not necessary for a bronze candidate							Comments: It is important for a candidate at Silver level to have working experience with virtual teams. Questions on this area should be on the exam.							Comments: It is extremely important for a Gold level to exemplify leadership in working as a virtual team. Questions on this area should be on the exam.						

Please rate or answer the following three items after you have completed rest of the survey:

(5 – Very High to   1- Very Low)

	5	4	3	2	1

1. How important are the results of this study (establishing/validating the body of knowledge for the discipline) to the field of Lean manufacturing?   ☐ ☐ ☐ ☐ ☐

2. Please rate the overall quality of this study.   ☐ ☐ ☐ ☐ ☐

3. Please provide any additional comments you may have regarding the importance and/or quality of this study, and any suggestions you may have for possible improvement.

Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination? **I. ENABLERS FOR LEAN**	BRONZE (Tactical)					Necessary for Certification exam?		SILVER (Integrative)					Necessary for Certification exam?		GOLD (Strategic)					Necessary for Certification exam?	
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Yes	No	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Yes	No	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Yes	No
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	4	3	*2*	1	0	Yes	*No*	4	*3*	2	1	0	*Yes*	No	*4*	3	2	1	0	*Yes*	No
1.1.1.1 Business Vision 1.1.1.2 Business Mission 1.1.1.3 Business Purpose 1.1.1.4 Business Values, Philosophy, Ethics 1.1.1.5 Strategic Business Assessment 1.1.1.6 Strategy Development 1.1.1.7 Business Goals and Objectives 1.1.1.8 Core Competencies 1.1.1.9 Critical Success Factors	0%	7%	*72%*	19%	2%	16%	*84%*	5%	*83%*	12%	0%	0%	*100%*	0%	*100%*	0%	0%	0%	0%	*100%*	0%
Comments (Bronze):								Comments (Silver):							Comments (Gold):						
1.1.2. Respect for Humanity and Social Responsibility	4	3	2	*1*	0	Yes	*No*	4	3	*2*	1	0	Yes	*No*	4	3	*2*	1	0	Yes	No
1.1.2.1 Schools and Communities 1.1.2.2 Unions 1.1.2.3 Other Stakeholders	2%	9%	21%	*64%*	4%	7%	*93%*	5%	18%	*68%*	9%	0%	25%	*75%*	*50%*	43%	7%	0%	0%	*94%*	6%
Comments (Bronze):								Comments (Silver):							Comments (Gold):						
1.1.3. Long and Short-term Planning	4	3	*2*	1	0	*Yes*	No	4	*3*	2	1	0	*Yes*	No	4	*3*	2	1	0	*Yes*	No
1.1.3.1 Hoshin Planning & Policy Deployment 1.1.3.2 Execution and Metrics 1.1.3.3 Project Management	0%	12%	*79%*	9%	0%	*86%*	14%	14%	*82%*	4%	0%	0%	*100%*	0%	*96%*	4%	0%	0%	0%	*100%*	0%
Comments (Bronze):								Comments (Silver):							Comments (Gold):						

Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination?	BRONZE (Tactical)						SILVER (Integrative)						GOLD (Strategic)					
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?
I. ENABLERS FOR LEAN																		
1.1.4. Principles of Lean leadership	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐ / No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐ / No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐ / No ☐
1.1.4.1 Go and See	*93%*	7%	0%	0%	0%	*100%* / 0%	*97%*	3%	0%	0%	0%	*100%* / 0%	*96%*	0%	2%	2%	0%	*95%* / 5%
1.1.4.2 Defining Value vs. Non-value 1.1.4.3 Identifying Waste 1.1.4.4 Achieving Flow 1.1.4.5 Recognizing Normal vs. Abnormal 1.1.4.6 Respect for Humanity	Comments:						Comments:						Comments:					
1.1.5. Lean corporate culture	4 ☐	*3* ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐ / No ☐	*4* ☐	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐ / No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐ / No ☐
1.1.5.1 Value Stream Mapping	22%	*66%*	12%	0%	0%	*95%* / 5%	*88%*	12%	0%	0%	0%	*100%* / 0%	*98%*	2%	0%	0%	0%	*100%* / 0%
1.1.5.2 Kaizen Blitz Events 1.1.5.3 Continuous Improvement & Change 1.1.5.4 Communication of Business Values, Philosophy, Ethics 1.1.5.5 Change & knowledge management systems 1.1.5.6 Resource Standards & Measures for Business Results	Comments:						Comments:						Comments:					
1.2.1. Principles of empowerment	4 ☐	3 ☐	*2* ☐	1 ☐	0 ☐	*Yes* ☐ / No ☐	4 ☐	*3* ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐ / No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐ / No ☐
1.2.1.1 Communication	2%	17%	*67%*	14%	0%	*76%* / 24%	14%	*81%*	5%	0%	0%	*97%* / 3%	*91%*	5%	2%	2%	0%	*97%* / 3%
1.2.1.2 Delegation 1.2.1.3 Recognition 1.2.1.4 Rewards 1.2.1.5 Employee Satisfaction & Morale 1.2.1.6 Employee & Labor Relations	Comments:						Comments:						Comments:					

Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination?

I. ENABLERS FOR LEAN

	BRONZE (Tactical)			SILVER (Integrative)			GOLD (Strategic)		
	Extremely / Very / Moderately / Slightly / Not Important (4 3 2 1 0)	Necessary for Certification exam? (Yes / No)		Extremely / Very / Moderately / Slightly / Not Important (4 3 2 1 0)	Necessary for Certification exam? (Yes / No)		Extremely / Very / Moderately / Slightly / Not Important (4 3 2 1 0)	Necessary for Certification exam? (Yes / No)	
1.2.2. Employee training and development	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐	No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐	No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐	No ☐
1.2.2.1 Instructional Goals	5% 20% 58% 15% 2%	70%	30%	12% 81% 7% 0% 0%	98%	2%	86% 10% 2% 2% 0%	97%	3%
1.2.2.2 Skills Assessment 1.2.2.3 Continuous Learning Strategy 1.2.2.4 Cross-Training 1.2.2.5 Classroom and On-the-Job Training 1.2.2.6 Coaching & Mentoring	Comments:			Comments:			Comments:		
1.2.3. Teamwork	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐	No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐	No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐	No ☐
1.2.3.1 Cross-Functional Team Selection & Leadership	7% 39% 52% 2% 0%	98%	2%	88% 10% 2% 0% 0%	100%	0%	91% 7% 2% 0% 0%	98%	2%
1.2.3.2 Multi-Level Participation 1.2.3.3 Roles & Responsibilities 1.2.3.4 Decision-Making Types 1.2.3.5 Team Dynamics (Storming, norming, etc.)	Comments:			Comments:			Comments:		
1.2.4. Suggestion/Feedback/Appraisal System	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐	No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐	No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐	No ☐
1.2.4.1 Information Sharing	3% 24% 61% 10% 0%	78%	22%	14% 76% 8% 2% 0%	98%	2%	90% 8% 2% 0% 0%	98%	2%
	Comments:			Comments:			Comments:		

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Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination?	BRONZE (Tactical)					Necessary for Certification exam?		SILVER (Integrative)					Necessary for Certification exam?		GOLD (Strategic)					Necessary for Certification exam?	
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important		
I. ENABLERS FOR LEAN	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
1.2.5. Employee Turnover, Absenteeism and Compensation	☐	☐	☐	*1* ☐	☐	☐	*No* ☐	☐	☐	*2* ☐	☐	☐	☐	*No* ☐	*4* ☐	☐	☐	☐	☐	☐	☐
	0%	5%	19%	66%	10%	9%	91%	2%	20%	70%	8%	0%	27%	73%	56%	39%	2%	3%	0%	93%	7%
	Comments:							Comments:							Comments:						
1.2.6. Ergonomic, clean and safe work environment, and results 1.2.6.1 Environment 1.2.6.2 Ergonomics 1.2.6.3 Safety	*4* ☐	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐	No ☐	*4* ☐	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐
	76%	17%	5%	2%	0%	95%	5%	91%	7%	2%	0%	0%	100%	0%	93%	3%	2%	2%	0%	98%	2%
	Comments:							Comments:							Comments:						
Additional Areas from Pre-Delphi	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
Motivation Theory	4 ☐	3 ☐	*2* ☐	1 ☐	0 ☐	Yes ☐	*No* ☐	4 ☐	*3* ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	*4* ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐
	5%	12%	57%	21%	5%	20%	80%	10%	65%	25%	0%	0%	85%	15%	75%	21%	4%	0%	0%	88%	12%
	Comments:							Comments:							Comments:						
Socio-technical Systems (An approach to design work that involves the interaction between people & technology at workplace)	4 ☐	3 ☐	2 ☐	*1* ☐	0 ☐	Yes ☐	*No* ☐	4 ☐	*3* ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	*3* ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐
	2%	4%	19%	67%	9%	7%	93%	5%	51%	44%	0%	0%	69%	31%	31%	52%	17%	0%	0%	78%	22%
	Comments:							Comments:							Comments:						

Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination? **II. LEAN CORE OPERATIONS**	BRONZE (Tactical)					Necessary for Certification exam?		SILVER (Integrative)					Necessary for Certification exam?		GOLD (Strategic)					Necessary for Certification exam?	
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important		
2.1.1. Operational Vision and Strategy	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	*No* ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	*4* ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐
2.1.1.1 Operation Processes Vision, Mission, Strategy & Goals	0%	11%	**72%**	17%	0%	19%	81%	10%	**80**%	10%	0%	0%	98%	2%	**93**%	5%	2%	0%	0%	100%	0%
2.1.1.2 Lean Principles in Strategy 2.1.1.3 Empowerment in Strategy 2.1.1.4 Operational Alignment with Organizational Vision, Mission, Strategy & Goals	Comments:							Comments:							Comments:						
2.2.1 Product Design and Development	4 ☐	*3* ☐	*2* ☐	1 ☐	0 ☐	Yes ☐	*No* ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	*4* ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐
2.2.1.1 Quality Function Deployment	4%	10%	**68%**	18%	0%	33%	67%	12%	**79**%	9%	0%	0%	100%	0%	**86**%	14%	0%	0%	0%	100%	0%
2.2.1.2 Concurrent Engineering 2.2.1.3 Variety Reduction 2.2.1.4 Engineering Changes 2.2.1.5 Design for Manufacture & Assembly 2.2.1.6 Design for Product Life Cycle (DFx) 2.2.1.7 Failure Mode & Effects Analysis (FMEA) 2.2.1.8 Life Cycle Engineering 2.2.1.9 Production Process Preparation (3P) 2.2.1.10 Knowledge Transfer Methods &	Comments:							Comments:							Comments:						

Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination? II. LEAN CORE OPERATIONS	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?	
2.2.2. Product Market Service	4 ☐	3 ☐	2 ☐	*1* ☐	0 ☐	*Yes* ☐	*No* ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐	No ☐	*4* ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐
2.2.2.1 Customer Feedback & Market Needs Analysis	0%	2%	30%	57%	11%	7%	93%	4%	51%	45%	0%	0%	67%	33%	71%	27%	2%	0%	0%	96%	4%
2.2.2.2 Customer Specs and Requirements 2.2.2.3 New market development & current market exploitation 2.2.2.4 E-commerce systems 2.2.2.5 Benchmarking	Comments:							Comments:							Comments:						
2.3.1. Suppliers	4 ☐	*3* ☐	*2* ☐	1 ☐	0 ☐	Yes ☐	*No* ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ☐	No ☐	*4* ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐
2.3.1.1 Supplier Development Processes	0%	45%	45%	7%	3%	26%	74%	5%	86%	7%	2%	0%	97%	3%	88%	9%	3%	0%	0%	100%	0%
2.3.1.2 Supplier Certification 2.3.1.3 Supplier Benchmarking 2.3.1.4 Supplier Satisfaction Measures 2.3.1.5 Corrective Action System	Comments:							Comments:							Comments:						
2.3.2 Customers	4 ☐	3 ☐	2 ☐	*1* ☐	0 ☐	Yes ☐	*No* ☐	4 ☐	*3* ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	*4* ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐
2.3.2.1 Customer Training & Development Processes	0%	4%	32%	59%	5%	25%	75%	9%	70%	19%	2%	0%	93%	7%	88%	12%	0%	0%	0%	100%	0%
2.3.2.2 Customer Selection Focus 2.3.2.3 Demand Load Leveling 2.3.2.4 Corrective Action System	Comments:							Comments:							Comments:						

Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination? **II. LEAN CORE OPERATIONS**	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?	
	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
2.3.3. Distribution & Transport Alliances	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2.3.3.1 Warehousing	0%	5%	64%	31%	0%	10%	90%	2%	74%	24%	0%	0%	93%	7%	73%	27%	0%	0%	0%	100%	0%
2.3.3.2 Distribution Centers	Comments:							Comments:							Comments:						
2.3.3.3 Cross-Docks																					
2.3.3.4 Reverse Logistics																					
2.3.3.5 Remanufacturing/ Maintenance, Repair and Overhaul (MRO)																					
2.3.3.6 Just-in-Time Alliances																					
2.3.3.7 Supplier Managed Inventory Systems																					
2.4.1. Systematic identification and elimination of waste	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2.4.1.1 Waste Identification and elimination of waste	93%	7%	0%	0%	0%	100%	0%	95%	5%	0%	0%	0%	100%	0%	93%	3%	2%	2%	0%	93%	7%
2.4.1.2 Value Stream Mapping	Comments:							Comments:							Comments:						
2.4.1.3 Value Analysis																					
2.4.1.4 5S Standards & Discipline																					
2.4.1.5 Visual Workplace																					
2.4.1.6 Kaizen Blitz Events																					
2.4.1.7 Mistake Proofing																					
2.4.1.8 Source Inspection																					
2.4.1.9 Continuous Improvement																					
2.4.1.10 Five Why's Problem Solving																					

Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination?

II. LEAN CORE OPERATIONS

	BRONZE (Tactical)		SILVER (Integrative)		GOLD (Strategic)	
	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important	Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important	Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important	Necessary for Certification exam?
2.4.2. Just-in-Time Operations	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ No ☐
2.4.2.1 Takt Time	88% 12% 0% 0% 0%	100% 0%	97% 3% 0% 0% 0%	100% 0%	91% 7% 2% 0% 0%	97% 3%
2.4.2.2 Material Signals	Comments:		Comments:		Comments:	
2.4.2.3 Pull System						
2.4.2.4 Continuous Flow						
2.4.2.5 Just-in-Time (JIT)						
2.4.2.6 Setup Reduction (SMED)						
2.4.2.7 Total Productive Maintenance (TPM)						
2.4.2.8 Load-Leveling (Heijunka)						
2.4.3. Cellular & Continuous Flow	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ No ☐
2.4.3.1 Cellular Manufacturing	89% 11% 0% 0% 0%	100% 0%	97% 3% 0% 0% 0%	100% 0%	86% 10% 0% 2% 2%	91% 9%
2.4.3.2 One Piece Flow	Comments:		Comments:		Comments:	
2.4.3.3 Standard Work						
2.4.3.4 Multi-process Handling						
2.4.3.5 Autonomation						
2.4.3.6 Production Schedule						
2.4.3.7 Bills of Materials						
2.4.3.8 Routings						
2.4.3.9 Flow Analysis Charts						

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Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination? **II. LEAN CORE OPERATIONS**	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?	
	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
2.4.4. Lean Tools for Continuous Improvement	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2.4.4.1 Plan-Do-Check-Act	91%	7%	2%	0%	0%	100%	0%	96%	4%	0%	0%	0%	100%	0%	89%	7%	2%	0%	2%	91%	9%
2.4.4.2 Reliability & maintainability 2.4.4.3 Root Cause & Corrective Action 2.4.4.4 Flow Charting 2.4.4.5 Pareto 2.4.4.6 Cause & effect Diagrams 2.4.4.7 Check Sheets 2.4.4.8 Histograms 2.4.4.9 Scatter & Concentration 2.4.4.10 Control Charts 2.4.4.11 Problem Solving Storyboards	Comments:							Comments:							Comments:						
Additional Areas from Pre-Delphi	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
Six Sigma/Problem Solving Techniques	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	9%	8%	59%	19%	5%	29%	71%	16%	55%	22%	4%	3%	79%	21%	55%	31%	9%	2%	3%	86%	14%
	Comments:							Comments:							Comments:						
Quantitative Decision Making Techniques	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	6%	11%	58%	16%	9%	29%	71%	15%	54%	25%	0%	6%	80%	20%	61%	27%	4%	2%	6%	85%	15%
	Comments:							Comments:							Comments:						

II. Additional Areas from Pre-Delphi	BRONZE (Tactical)		SILVER (Integrative)		GOLD (Strategic)	
	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?
Simulation Technique	4 3 2 *1* 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ *No* ☐	4 *3* 2 1 0 ☐ ☐ ☐ ☐ ☐	*Yes* ☐ No ☐	4 *3* 2 1 0 ☐ ☐ ☐ ☐ ☐	*Yes* ☐ No ☐
	2% 3% 23% *62%* 10%	14% *86%*	3% *47%* 37% 10% 3%	*59*% 41%	14% *59%* 22% 2% 3%	*71*% 29%
	Comments:		Comments:		Comments:	
Optimization Techniques	4 3 2 *1* 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ *No* ☐	4 3 *2* 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ *No* ☐	4 *3* 2 1 0 ☐ ☐ ☐ ☐ ☐	*Yes* ☐ No ☐
	0% 5% 24% *62%* 9%	7% *93%*	5% 21% *60%* 12% 2%	49% *51%*	22% *59%* 14% 3% 2%	*78*% 22%
	Comments:		Comments:		Comments:	
Facilities Design and Layout	4 3 *2* 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ *No* ☐	4 *3* 2 1 0 ☐ ☐ ☐ ☐ ☐	*Yes* ☐ No ☐	*4* 3 2 1 0 ☐ ☐ ☐ ☐ ☐	*Yes* ☐ No ☐
	3% 17% *61%* 17% 2%	36% *64%*	20% *64*% 12% 2% 2%	*86*% 14%	*64%* 30% 2% 2% 2%	*97*% 3%
	Comments:		Comments:		Comments:	
III. BUSINESS CORE OPERATIONS-SUPPORT FUNCTIONS	BRONZE (Tactical)		SILVER (Integrative)		GOLD (Strategic)	
	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?
3.1.1 Administrative Vision & Strategy	4 *3* 2 1 0 ☐ ☐ ☐ ☐ ☐	*Yes* ☐ No ☐	4 *3* 2 1 0 ☐ ☐ ☐ ☐ ☐	*Yes* ☐ No ☐	*4* 3 2 1 0 ☐ ☐ ☐ ☐ ☐	*Yes* ☐ No ☐
3.1.1.1 Application of Lean principles & techniques	2% 18% *75%* 5% 0%	*81*% 19%	17% *80*% 3% 0% 0%	*98*% 2%	*91*% 9% 0% 0% 0%	*100*% 0%
3.1.1.2 Focus on value adds & waste identification & elimination 3.1.1.3 Commitment to Continuous Improvement 3.1.1.4 Business operations improvement metrics	Comments:		Comments:		Comments:	

III. BUSINESS CORE OPERATIONS-SUPPORT FUNCTIONS	BRONZE (Tactical)		SILVER (Integrative)		GOLD (Strategic)	
	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?
3.1.2. Alignment & Systematic Business & Service Process Design	4　3　**2**　1　0　☐☐☐☐☐	Yes　*No*　☐　☐	4　**3**　2　1　0　☐☐☐☐☐	*Yes*　No　☐　☐	*4*　3　2　1　0　☐☐☐☐☐	*Yes*　No　☐　☐
3.1.2.1 Finance & Accounting: Measurement & control systems,etc	0% 7% **69**% 22% 2%	19%　*81%*	12% **76**% 10% 2% 0%	*93%*　7%	**88**% 10% 0% 2% 0%	*98%*　2%
3.1.2.2 Human Resources: Alignment of selection, development, teamwork, performance feedback & discipline, compensation & rewards, etc. 3.1.2.3 Materials Management:Inventory Control,planning&scheduling,logistics, etc 3.1.2.4 Information Technology:Appropriate alignment with process changes, accessibility,etc 3.1.2.5 Sales&Marketing:Alignment of sales&operations planning&execution,etc 3.1.2.6 Quality Assurance: Regulation & certification, inspection rationale, etc 3.2.1.7 Process & Manufacturing Engineering: System for engineering changes, concurrent 3.2.1.8 Legal & Regulatory: Alignment with core lean thinking, etc	Comments:		Comments:		Comments:	
Supply Chain Logistics	4　3　**2**　1　0　☐☐☐☐☐	Yes　*No*　☐　☐	4　**3**　2　1　0　☐☐☐☐☐	*Yes*　No　☐　☐	*4*　3　2　1　0　☐☐☐☐☐	*Yes*　No　☐　☐
	0% 6% **65**% 29% 0%	14%　*86%*	8% **70**% 22% 0% 0%	*90*%　10%	75% 19% 6% 0% 0%	*98*%　2%
	Comments:		Comments:		Comments:	
Lean Accounting	4　3　2　*1*　0　☐☐☐☐☐	Yes　*No*　☐　☐	4　**3**　2　1　0　☐☐☐☐☐	*Yes*　No　☐　☐	*4*　3　2　1　0　☐☐☐☐☐	*Yes*　No　☐　☐
	2% 3% 22% **68**% 5%	7%　93%	3% **54**% 39% 4% 0%	*78*%　22%	71% 25% 0% 4% 0%	*97*%　3%
	Comments:		Comments:		Comments:	
Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	4　3　**2**　1　0　☐☐☐☐☐	Yes　*No*　☐　☐	4　3　**2**　1　0　☐☐☐☐☐	*Yes*　No　☐　☐	*4*　3　2　1　0　☐☐☐☐☐	*Yes*　No　☐　☐
	4% 2% **60**% 31% 3%	14%　86%	7% 31% **55**% 3% 4%	*71*%　29%	**51**% 35% 7% 2% 5%	*88*%　12%
	Comments:		Comments:		Comments:	

Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination? **IV. QUALITY, COST & DELIVERY MEASURES**	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	\multicolumn{2}{c}{Necessary for Certification exam?}	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	\multicolumn{2}{c}{Necessary for Certification exam?}	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	\multicolumn{2}{c}{Necessary for Certification exam?}
4.1.1 Quality Results	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐
4.1.1.1 Rework	79%	19%	2%	0%	0%	97%	3%	85%	12%	3%	0%	0%	100%	0%	97%	3%	0%	0%	0%	97%	3%
4.1.1.2 Customer PPM Rejects 4.1.1.3 First Pass Yield 4.1.1.4 Scrap 4.1.1.5 Process Variation 4.1.1.6 Cost of Quality 4.1.1.7 Warranty Costs	Comments:							Comments:							Comments:						
4.2.1 Cost & Productivity Results	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐	4 ☐	3 ☐	2 ☐	1 ☐	0 ☐	Yes ☐	No ☐
4.2.1.1 Inventory Turns	84%	14%	2%	0%	0%	98%	2%	95%	5%	0%	0%	0%	100%	0%	96%	2%	2%	0%	0%	98%	2%
4.2.1.2 Record Accuracy 4.2.1.3 Cycle Time, Takt Time and Throughput Time 4.2.1.4 Operational Equipment Effectiveness (OEE) 4.2.1.5 Labor Value-Add 4.2.1.6 Product Cost Reduction 4.2.1.7 Changeover 4.2.1.8 Resource Utilization 4.2.1.9 Energy Efficiency 4.2.1.10 Performance to Load Leveling	Comments:							Comments:							Comments:						

Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination? **IV. QUALITY, COST & DELIVERY MEASURES**	BRONZE (Tactical)			SILVER (Integrative)			GOLD (Strategic)		
	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important		Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important		Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important		Necessary for Certification exam?
4.3.1 Delivery and Customer Service Measurement	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐		Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐		Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐		Yes ☐ No ☐
4.3.1.1 Line-Items Delivered On-Time to Customer Requirement	14% *56*% 22% 8% 0%		*78*% 22%	69% 29% 2% 0% 0%		98% 2%	92% 5% 3% 0% 0%		95% 5%
4.3.1.2 Complete Orders Delivered On-Time to Customer Requirements 4.3.1.4 Premium Freight 4.3.1.5 Mistakes in Shipment 4.3.1.6 Warranty Response, Service, etc.	Comments:			Comments:			Comments:		
Additional Areas from Pre-Delphi	BRONZE (Tactical)			SILVER (Integrative)			GOLD (Strategic)		
International Organization for Standardization (ISO) and Lean	4 3 *2* 1 0 ☐ ☐ ☐ ☐ ☐		Yes ☐ *No* ☐	4 3 *2* 1 0 ☐ ☐ ☐ ☐ ☐		Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐		*Yes* ☐ No ☐
	4% 10% *49*% 32% 5%		12% 88%	3% 29% *61*% 5% 2%		61% 39%	49% 30% 17% 2% 2%		86% 14%
	Comments:			Comments:			Comments:		
Quality Management System (QMS)	4 3 *2* 1 0 ☐ ☐ ☐ ☐ ☐		Yes ☐ *No* ☐	4 *3* 2 1 0 ☐ ☐ ☐ ☐ ☐		Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐		*Yes* ☐ No ☐
	3% 7% *68*% 17% 5%		22% 78%	5% *52*% 36% 2% 5%		69% 31%	58% 30% 17% 0% 5%		83% 17%
	Comments:			Comments:			Comments:		

Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination?	BRONZE (Tactical) Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important	Necessary for Certification exam?	SILVER (Integrative) Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important	Necessary for Certification exam?	GOLD (Strategic) Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important	Necessary for Certification exam?
5.1.1 Customer Satisfaction Results	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ No ☐
5.1.1.1 Market Share 5.1.1.2 Reorder Rate 5.1.1.3 Customer Survey Results 5.1.1.4 Customer Audit Results 5.1.1.5 Other Customer Feedback 5.1.1.6 Value/Improvement Analysis 5.1.1.7 Customer Retention 5.1.1.8 Customer Awards	2% 5% 66% 25% 2% Comments:	16% 84%	3% 75% 22% 0% 0% Comments:	91% 9%	81% 17% 2% 0% 0% Comments:	97% 3%
5.2.1. Profitability Measurement	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ No ☐
5.2.1.1 Operating Income on Sales & Assets 5.2.1.2 Operating Income on Space 5.2.1.3 Fixed & Variable Costs 5.2.1.4 Cash Flow 5.2.1.5 Value Stream Profitability	5% 2% 24% 63% 6% Comments:	15% 85%	5% 63% 27% 3% 2% Comments:	88% 12%	81% 17% 0% 0% 2% Comments:	98% 2%
Additional Areas from Pre-Delphi	BRONZE (Tactical)		SILVER (Integrative)		GOLD (Strategic)	
Lean Business Metrics	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ No ☐
	7% 10% 70% 8% 5% Comments:	44% 56%	14% 78% 7% 0% 1% Comments:	95% 5%	90% 8% 0% 0% 2% Comments:	97% 3%
Total Supply Chain Cost	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ No ☐	4 3 2 1 0 ☐ ☐ ☐ ☐ ☐	Yes ☐ No ☐
	5% 0% 22% 66% 7% Comments:	9% 91%	5% 66% 24% 5% 0% Comments:	80% 20%	81% 15% 2% 2% 0% Comments:	98% 2%

Additional Comments if Any:

Thank you for your time and effort!

Subject: Delphi Round Three Reminder

Dear Lean Delphi Panel Expert:

We recently sent out our third Delphi questionnaire for the final round of our Lean Certification Role Delineation Study. We are looking forward to your continued and final participation as a Delphi panel member expert for our study. If you have not yet had a chance to complete the Round Three questionnaire, please try to do so and mail it back to me as soon as possible.

If you have not yet received the Round Three questionnaire, please email me at: hiral.shah@emich.edu and I will send one to you immediately. *If you prefer filling in an electronic format, then please email me and I will send you an electronic copy of the survey.*

We hope to receive replies from all members of Delphi panel by mid-June. We can then analyze the qualitative and quantitative data and provide a final report of the results to you and the sponsoring organizations of the lean certification program.

Your contribution and commitment to our study is most valued, and is essential to assuring validity in this research to create a standardized body of knowledge for the Lean manufacturing discipline. We very much appreciate your time, effort, and contribution.

Thank you in advance!

Sincerely,

Ms. Hiral Shah, Researcher　　　　　**Dr. Tracy Tillman, CMfgE, CEI/CEM**
Eastern Michigan University　　　　　　Chair, Ph.D. Dissertation Committee
hiral.shah@emich.edu　　　　　　　　　Eastern Michigan University

Sub: Lean Delphi Round Three Reminder   **Date: June 11, 2007**

Dear Lean Delphi Panel Expert,

We hope that you received the final round of Delphi questionnaire that we sent out to you a few weeks ago. Our goal is to delineate a standardized body of knowledge for the SME/AME/Shingo Lean manufacturing certification program. If you have not already done so, please take a few minutes to complete the Round Three Delphi questionnaire that you received and return it to me as soon as possible.

If you need or prefer to use an electronic version of the survey, then please email me at hiral.shah@emich.edu and I will email one to you immediately.

Your continued participation in the final round of our study is essential to helping us develop a valid research-based standardized body of knowledge for the field of Lean manufacturing. Our results will help to make the SME/AME/Shingo lean certification program more robust, and help to guide training, curriculum development, and future growth and development in other areas of lean manufacturing. We sincerely appreciate your time, effort and contribution.

Respectfully,

Ms. Hiral Shah, Researcher   Dr. Tracy Tillman, Dissertation Chair
Eastern Michigan University   Eastern Michigan University

Subject: Lean Delphi Study -- Round Three Reminder

Dear :

Recently we sent you the final round of our Delphi questionnaire for our Lean Certification Role Delineation Study, but did not receive your response. Since this study is ground breaking and first of its kind, we have utilized a Delphi technique to obtain a convergence of opinion across three rounds of the questionnaire. Therefore, it is very important that you participate in this last round and express your ratings and comments on each of the competency areas included in the Body of Knowledge developed by SME/AME/Shingo consortium.

In order to expedite the process, I have attached an electronic copy of Round Three questionnaire along with the results from Round Two. Please take a few moments to complete the survey and email me back your responses at your earliest.

After receiving your responses, we will analyze both the qualitative and quantitative data obtained from three rounds and send you the final results of the study. Your participation and expertise is very valuable in order to assure validity in this research and to create a standardized body of knowledge for the Lean manufacturing discipline.

We are extremely thankful to you for your interest and participation in this study and very much value your time and efforts involved. We are looking forward to your continued participation as a Delphi panel expert in the final round of our study.

Sincerely,

Ms. Hiral Shah, Researcher   **Dr. Tracy Tillman, CMfgE, CEI/CEM**
Eastern Michigan University   Chair, Ph.D. Dissertation Committee
hiral.shah@emich.edu   Eastern Michigan University

P.S. If you have already mailed in your responses then please ignore this email.

Appendix I

Final Report to the Delphi Panel

August 27, 2007

Dear

Thank you so much for your participation as a Delphi panel expert in our role delineation study for the SME/AME/Shingo Lean certification program. Your prompt and thorough responses reflect the high level of professionalism and expertise that was prevalent among our panel of experts. With your interest, enthusiasm, and support we obtained a response rate of over 70% in each of the rounds of the Delphi study, including a 75% response rate for Round Three of our study. This high response rate has helped us to obtain valid results and enhances the importance and usefulness of our study to the field of Lean manufacturing.

As promised at the beginning of our study, we are sharing the overall results via the enclosed final report. This report includes the following: (a) background information of the Delphi panel members, (b) results on importance and overall quality of the study from Round Three, (c) prioritized list of competency areas from Round Three results, and (d) recommended body of knowledge for developing the table of specifications for the examinations in the SME/AME/Shingo Lean certification program.

In addition to ratings of importance of competency areas, the qualitative comments provided by the Delphi panelists were very helpful as guidance on how to handle some complex issues regarding some competency areas. Details regarding specific quantitative and qualitative analysis for this study will be available later this year in my published dissertation. As mentioned previously, your specific responses will be kept anonymous. If you have any questions regarding the methodology used for this study, please email me or Dr. Tracy Tillman.

We hope that the results of our study will help to make the SME/AME/Shingo lean certification program more robust, and serve to guide training, curriculum development, and future growth and development in other areas of lean manufacturing. If you have any questions regarding the application of the results of this study, please contact SME's certification department.

Again, we sincerely appreciate the time and effort you gave on this research project. It was a great pleasure to work with you.

Sincerely,

Ms. Hiral Shah, Researcher   Dr. Tracy Tillman, Dissertation Chair
Eastern Michigan University   Eastern Michigan University
Email: hiral.shah@emich.edu   Email: drttemu@aol.com

Society of
Manufacturing
Engineers

August 27, 2007

Dear

On behalf of the Society of Manufacturing Engineers, the Association for Manufacturing Excellence, and the Shingo Prize for Excellence in Manufacturing, I want to personally thank you for your active participation as a Delphi panel expert in the role delineation study conducted by Hiral Shah (under the direction of Tracy Tillman, PhD) for our multi-level Lean certification program.

A role delineation study is used to (a) analyze the knowledge and skills needed for competent job performance in a specific occupation, profession, or discipline and to (b) specify a body of knowledge and table of specifications for development of a certification or licensure examination for that specific occupation, profession, or discipline. The role delineation study recently completed for us by Ms. Shah is part of our continuous improvement (Kaizen) efforts and will help us to assure that we are providing a valid, fair, and defensible set of Lean certification examinations and portfolio requirements to the public.

It is very impressive to see that we achieved more than a 70% response rate in each of the three rounds of our Delphi study. This high response rate, in comparison to the 10% to 30% response rates obtained by typical business surveys, reflects the enthusiasm and support of the Delphi panel experts, and demonstrates recognition of the importance the study for the lean manufacturing discipline. The high response rate and quality of participation by the panel of experts has provided us with rich qualitative and quantitative information — and most importantly — valid and reliable results.

This study would not have been such a success without your support. I sincerely appreciate the time and energy you have devoted to this research project and wish you success in your lean mission and professional career. And I invite you to view the Lean Certification program in its entirety at www.sme.org/leancert.

Best regards,

Jeannine Kunz

Jeannine Kunz
Manager, Certification

FINAL RESULTS OF THE SME/AME/SHINGO

LEAN CERTIFICATION ROLE DELINEATION STUDY

By

Hiral A. Shah, CEI, CEM, CAPM

A Report

Submitted to the:

Delphi Panel Members of the Lean Certification Study

August 2007

Ypsilanti, Michigan

TABLE OF CONTENTS

INTRODUCTION

The purpose of this role delineation study was to validate and prioritize the competency areas included in the body of knowledge of the Lean certification examination developed by a consortium of Society of Manufacturing Engineers, Association for Manufacturing Excellence, and Shingo Prize for Excellence in Manufacturing. Detailed results from Round Three of the study are provided in a separate document for your reference. The following report will summarize the final results of the study.

Background of the Delphi Panel Members

Table 1 below contains the demographic information provided by the Delphi panel experts selected to serve on this study. Based on the responses obtained from the pre-Delphi round, 76 panel members were selected to participate in the study based on their expertise, experience, and commitment to participation in the study.

Table 1. Demographic Information of the Delphi Panel Experts

Demographic Questions	N	Percent
1. What is your age group?		
Under 25	--	
25-34	10	13
35-44	22	29
45-54	22	29
55-64	17	22
65 or over	5	7
2. What is the highest level of education that you have completed?		
High School	4	5
Associate Degree	4	5
Bachelor's Degree	24	32
Master's Degree	35	46
Doctorate	7	9
Other – DD, Several college years	2	3
3. Which of the following professional designations do you hold?		
CEI	1	1
CEM	1	1
PE	8	10
CMfgE	3	4
CMfgT	3	4
None	44	56
Other (please specify) – *ASQ_CSSBB; Bachelor in Engineering & Fulbright Fellow from Carnegie; CDP, CSP, CFPIM, CIRM; CQM, CQEgr; Chartered Engineer (similar to PE); Chemical*	18	24

*Engineer; CQE, CQA, CMGR; CSSMBB, CLS, CMC; Diploma-Ing;
EIT, Electrical Engineer; EMCP; GE Black Belt; Industrial
Engineering; Journeyman tool and die maker; Lean Certification
Bronze Level; Lean Six Sigma Champion, ASQ CQE;* PMP; SME
Bronze Lean

	N	**Percent**
4. Which of the following most closely describes your current position within your organization?		
Senior Management	22	29
Mid-level Management	18	24
Consulting/Private Practice	10	13
College/University Faculty	4	5
Design/Engineering	2	3
Manufacturing/Operations/Quality/Support	12	16
Other (please specify) – *Consultant; Internal consultant; Lean Champion; Lean Coordinator; Owner; Retired; Six Sigma Black Belt; Sr. Management of Company*	8	10
5. Which of the following best describes the place of your residence?		
Northcentral United States (IL,IA,KS,MI,MN,MO,NE,SD,WI)	19	25
Northwest United States (ID, MT, OR, WA, WY)	1	1
Southwest United States (AZ, CA, CO, NM, NV, UT)	10	13
Northeast United States (CT,DC,DE,IN,KY,MA,MD,NH,NJ,NY, OH, PA, RI,VA,VT,WV)	19	25
Southeast United States (AL,AR,FL,LA,MS,NC,OK,SC,TX, TN)	14	18
Canada	8	10
Mexico	0	--
Other (Please specify the Country) – *Denmark, United Arab Emirates, Dominican Republic, Puerto Rico*	5	7
6. Please rate your level of expertise in the field of Lean Manufacturing.		
1-Very Low	--	--
2-Low	--	--
3-Medium	21	29
4-High	36	49
5-Very High	19	22
7. How many years of lean manufacturing related work experience do you have?		
0 to 5 years	17	22
6 to 10 years	24	32
11 to 15 years	19	25
15 to 20 years	4	5
More than 20 years	12	16

	N	Percent
8. Please indicate your level of commitment to serve as an expert on the Delphi panel and complete all three rounds of Delphi Study.		
1-Very Low	--	--
2-Low	--	--
3-Medium	21	28
4-High	36	47
5-Very High	19	25

Results on Importance and Overall Quality of the Study

Table 2 contains results based on questions added to the Round Three questionnaire regarding the importance and overall quality of the study. A majority of the Delphi panel experts indicated that the results of this study were either of very high or high importance to the field of Lean manufacturing. Moreover, predominant responses for the overall quality of the study ranged from very high to high.

Table 2. Results on Importance and Overall Quality of the Study from Round Three

	Very High 5	High 4	Medium 3	Low 2	Very Low 1	TOTAL
Importance of the results of this study to the field of Lean manufacturing	36%	57%	2%	3%	2%	53
Overall Quality of study	32%	51%	15%	2%	0%	53

Prioritized List of Competency Areas

A prioritized list of competency areas for the Lean Bronze, Silver, and Gold levels of examinations is given in the following Tables 3, 4, and 5, based on mean and standard deviation scores from ratings of 5 (very high) to 1 (very low). The competency areas have been grouped under each domain and are categorized by low and high standard deviations. **The competency areas in bold represent high mean and low standard deviation (higher degree of consensus among panel members),** and those not in bold represent lower degree of agreement among panel members with either high or low mean values. Y% represents the "Yes" percentage of responses obtained from the "Necessary for Certification Exam?" question.

Table 3. Prioritized list of Competency Areas from the Lean Bronze Certification Level

Competency Areas	Mean	SD	Y%
I. ENABLERS FOR LEAN			
1.1.4. Principles of Lean leadership	**3.96**	**0.187**	**100**
1.2.6. Ergonomic, clean and safe work environment, and results	**3.79**	**0.453**	**98.2**
1.1.5. Lean Corporate Culture	**3.09**	**0.405**	**96.2**
1.2.3. Teamwork	2.39	0.685	92.3
1.2.2. Employee training and development	**2.21**	**0.559**	**81.8**
1.2.1. Principles of Empowerment	2.21	0.674	82.1
1.2.4. Suggestion/Feedback/Appraisal System	**2.05**	**0.553**	**81.8**
1.1.3. Long and Short-term Planning	**2.04**	**0.499**	**81.5**
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	1.95	0.61	15.8
Motivation Theory	1.75	0.714	10.7
1.1.2. Respect for Humanity and Social Responsibility	1.29	0.731	9.1
Socio-technical Systems	1.18	0.601	5.5
1.2.5. Employee Turnover, Absenteeism, and Compensation	1.14	0.718	1.8
II. LEAN CORE OPERATIONS			
2.4.3. Cellular & Continuous Flow	**3.93**	**0.26**	**100**
2.4.2. Just-in-Time Operations	**3.91**	**0.29**	**100**
2.4.1. Systematic identification and elimination of waste	**3.91**	**0.348**	**98.1**
2.4.4. Lean Tools for Continuous Improvement	**3.86**	**0.398**	**100**
2.3.1. Suppliers	2.23	0.708	23.2
2.1.1. Operational Vision and Strategy	**2.04**	**0.533**	**10.7**
2.2.1 Product Design and Development	2.04	0.731	27.3
Facilities Design and Layout	1.91	0.606	25
Six Sigma/Problem Solving Techniques	1.84	0.682	14.5
Quantitative Decision-Making Techniques	1.78	0.686	15.1
2.3.3. Distribution & Transport Alliances	1.77	0.572	7.3
2.3.2 Customers	1.4	0.776	14.3
2.2.2. Product Market Service	1.21	0.647	7.1
Optimization Techniques	1.18	0.71	5.4
Simulation Technique	1.14	0.743	7.3

Competency Areas	Mean	SD	Y%
III. BUSINESS CORE OPERATIONS – SUPPORT FUNCTIONS			
3.1.1 Administrative Vision & Strategy	**2.07**	**0.563**	**83.9**
Supply Chain Logistics	1.91	0.64	7.3
3.1.2. Alignment & Systematic Business & Service Process Design	1.86	0.616	5.5
Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	1.8	0.737	9.4
Lean Accounting	1.34	0.769	9.1
IV. QUALITY, COST & DELIVERY MEASURES			
4.1.1 Quality Results	**3.8**	**0.447**	**100**
4.2.1 Cost & Productivity Results	**3.77**	**0.632**	**98.2**
4.3.1 Delivery and Customer Service Measurement	**2.79**	**0.594**	**89.1**
Quality Management System (QMS)	1.96	0.719	14.8
International Organization for Standardization (ISO) and Lean	1.79	0.706	7.3
V. BUSINESS RESULTS			
Lean Business Metrics	1.96	0.533	41.1
5.1.1 Customer Satisfaction Results	1.96	0.687	12.7
5.2.1. Profitability Measurement	1.4	0.743	18.9
Total Supply Chain Cost	1.3	0.737	5.6

Table 4. Prioritized list of Competency Areas from the Lean Silver Certification Level

Competency Areas	Mean	SD	Y%
I. ENABLERS FOR LEAN			
1.1.4. Principles of Lean leadership	**4.00**	**0.000**	**100.0**
1.1.5. Lean Corporate Culture	**3.96**	**0.192**	**100.0**
1.2.6. Ergonomic, clean and safe work environment, and results	**3.95**	**0.225**	**100.0**
1.2.3. Teamwork	**3.89**	**0.420**	**100.0**
1.2.2. Employee training and development	**3.09**	**0.391**	**100.0**
1.2.1. Principles of Empowerment	3.07	0.457	98.2

Competency Areas	Mean	SD	Y%
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	**3.04**	**0.186**	**98.0**
1.1.3. Long and Short-term Planning	2.96	0.376	98.1
1.2.4. Suggestion/Feedback/Appraisal System	2.96	0.466	96.4
Motivation Theory	2.74	0.695	85.7
Socio-technical Systems	2.53	0.570	71.4
1.1.2. Respect for Humanity and Social Responsibility	2.12	0.734	25.9
1.2.5. Employee Turnover, Absenteeism, and Compensation	2.02	0.582	17.9
II. LEAN CORE OPERATIONS			
2.4.3. Cellular & Continuous Flow	**3.98**	**0.134**	**100.0**
2.4.2. Just-in-Time Operations	**3.98**	**0.135**	**100.0**
2.4.4. Lean Tools for Continuous Improvement	**3.96**	**0.186**	**100.0**
2.4.1. Systematic identification and elimination of waste	**3.95**	**0.229**	**100.0**
2.2.1 Product Design and Development	**3.04**	**0.462**	**96.4**
Facilities Design and Layout	3.02	0.668	94.6
2.1.1. Operational Vision and Strategy	2.96	0.462	100.0
2.3.1. Suppliers	**2.93**	**0.417**	**96.4**
2.3.3. Distribution & Transport Alliances	**2.82**	**0.386**	**90.9**
Quantitative Decision-Making Techniques	2.80	0.621	79.6
Six Sigma/Problem Solving Techniques	2.75	0.640	83.6
2.3.2 Customers	2.74	0.613	91.1
2.2.2. Product Market Service	2.68	0.631	78.2
Simulation Technique	2.39	0.774	54.5
Optimization Techniques	2.07	0.704	32.1
III. BUSINESS CORE OPERATIONS – SUPPORT FUNCTIONS			
3.1.1 Administrative Vision & Strategy	**3.09**	**0.342**	**100.0**
3.1.2. Alignment & Systematic Business & Service Process Design	**2.89**	**0.528**	**94.5**
Supply Chain Logistics	2.88	0.470	90.9
Lean Accounting	2.63	0.590	80.0
Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	2.39	0.596	83.0

Competency Areas	Mean	SD	Y%
IV. QUALITY, COST & DELIVERY MEASURES			
4.2.1 Cost & Productivity Results	**3.93**	**0.260**	**100.0**
4.1.1 Quality Results	**3.89**	**0.369**	**98.1**
4.3.1 Delivery and Customer Service Measurement	**3.79**	**0.456**	**98.2**
Quality Management System (QMS)	2.75	0.700	85.2
International Organization for Standardization (ISO) and Lean	2.27	0.674	67.3
V. BUSINESS RESULTS			
Lean Business Metrics	**3.02**	**0.551**	**98.2**
5.1.1 Customer Satisfaction Results	**2.88**	**0.470**	**92.7**
5.2.1. Profitability Measurement	2.77	0.577	88.7
Total Supply Chain Cost	2.77	0.632	81.8

Table 5. Prioritized list of Competency Areas from the Lean Gold Certification Level

Competency Areas	Mean	SD	Y%
I. ENABLERS FOR LEAN			
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	**4.00**	**0.000**	**100**
1.1.4. Principles of Lean leadership	**4.00**	**0.000**	**98.2**
1.1.5. Lean Corporate Culture	**4.00**	**0.000**	**100**
1.1.3. Long and Short-term Planning	**3.95**	**0.225**	**100**
1.2.6. Ergonomic, clean and safe work environment, and results	**3.95**	**0.225**	**100**
1.2.3. Teamwork	**3.94**	**0.231**	**100**
1.2.1. Principles of Empowerment	3.93	0.258	100
1.2.2. Employee training and development	3.93	0.258	100
1.2.4. Suggestion/Feedback/Appraisal System	3.88	0.334	100
Motivation Theory	3.72	0.648	96.4
1.2.5. Employee Turnover, Absenteeism, and Compensation	3.37	0.771	91.1
1.1.2. Respect for Humanity and Social Responsibility	3.36	0.699	92.7
Socio-technical Systems	3.18	0.571	94.5

Competency Areas	Mean	SD	Y%
II. LEAN CORE OPERATIONS			
2.4.1. Systematic identification and elimination of waste	**3.96**	**0.189**	**96.3**
2.1.1. Operational Vision and Strategy	**3.95**	**0.225**	**100**
2.3.1. Suppliers	**3.91**	**0.285**	**100**
2.4.4. Lean Tools for Continuous Improvement	**3.91**	**0.285**	**96.4**
2.4.2. Just-in-Time Operations	**3.91**	**0.348**	**96.3**
2.2.1 Product Design and Development	**3.88**	**0.331**	**100**
2.3.2 Customers	**3.88**	**0.331**	**100**
2.4.3. Cellular & Continuous Flow	3.88	0.470	98.2
2.2.2. Product Market Service	**3.77**	**0.423**	**94.6**
2.3.3. Distribution & Transport Alliances	3.75	0.437	98.2
Facilities Design and Layout	3.65	0.767	92.9
Quantitative Decision-Making Techniques	3.64	0.729	92.6
Six Sigma/Problem Solving Techniques	3.48	0.831	90.9
Simulation Technique	2.86	0.811	74.5
Optimization Techniques	2.75	0.808	78.2
III. BUSINESS CORE OPERATIONS – SUPPORT FUNCTIONS			
3.1.1 Administrative Vision & Strategy	**3.96**	**0.186**	**100**
3.1.2. Alignment & Systematic Business & Service Process Design	**3.86**	**0.353**	**100**
Supply Chain Logistics	**3.77**	**0.426**	**100**
Lean Accounting	3.73	0.486	100
Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	3.46	0.665	92.5
IV. QUALITY, COST & DELIVERY MEASURES			
4.2.1 Cost & Productivity Results	**3.91**	**0.345**	**100**
4.1.1 Quality Results	**3.89**	**0.416**	**94.4**
4.3.1 Delivery and Customer Service Measurement	**3.88**	**0.429**	**98.2**
Quality Management System (QMS)	3.56	0.898	90.7
International Organization for Standardization (ISO) and Lean	3.38	0.776	90.9
V. BUSINESS RESULTS			
Lean Business Metrics	3.86	0.581	96.5
5.1.1 Customer Satisfaction Results	**3.84**	**0.417**	**98.2**
5.2.1. Profitability Measurement	**3.83**	**0.376**	**100**
Total Supply Chain Cost	3.75	0.640	98.2

An approach used by Shah (2004) and Tillman (1989) was used to group the competency areas into four major categories:

(a) Categories I and II contained Round Three mean ratings higher than 2.0 which implied higher than medium importance. Category I competency areas had lower standard deviation values, while Category II competency areas had higher standard deviation values.

(b) Categories III and IV contained other competency areas from Round Three with mean ratings less than 2.0 which implied less than medium importance. Category III competency areas had higher standard deviations, and Category IV had lower standard deviations.

Higher and lower values of standard deviations were determined based on the median value of standard deviation under each domain. In summary, the competency areas in:

Category I – High Mean Low Standard Deviation – Most likely included
Category II – High Mean High Standard Deviation – Likely included
Category III– Low Mean High Standard Deviation – Less likely included
Category IV– Low Mean Low Standard Deviation – Least likely not included

RECOMMENDED BODY OF KNOWLEDGE FOR THE SME/AME/SHINGO LEAN CERTIFICATION PROGRAM

An overall analysis to calculate the percentage of importance to each major domain in the body of knowledge was determined by a combined grand average of importance and "yes" percent ratings for each competency area within each domain. This approach is similar to the one used by Tillman (2000). Table 6 below shows a comparison of the percent distribution for each domain for Bronze, Silver, and Gold level exams obtained from the Delphi study with the existing body of knowledge.

Table 6. Comparison of Percentage of Importance to each Major Domain obtained from the Delphi Study with the Existing Distribution in the Current Body of Knowledge

Domain	Bronze (Delphi)	Bronze (Current BOK)	Silver (Delphi)	Silver (Current BOK)	Gold (Delphi)	Gold (Current BOK)
I. Enablers for Lean	33.0%	15%	31.1%	25%	31.4%	35%
II. Lean Core Operations	35.7%	45%	35.8%	35%	35.1%	15%
III. Business Core Operations		20%		15%		10%
– Support Functions	9.1%		11.1%		12.0%	
IV. Quality, Cost & Delivery		15%		10%		10%
Measures	15.5%		12.8%		11.8%	
V. Business Results	6.7%	5%	9.2%	15%	9.7%	30%
TOTAL	100%		100%		100%	

A thorough analysis on which competency areas should be included in the body of knowledge under each level of examination was made by collating the comments as well as the categorized list of competency areas. The qualitative comments supplemented the quantitative analysis of mean and standard deviation values and were highly important in determining which competency areas are important to be included in the body of knowledge of the Lean certification program. Table 7 below explains the recommended body of knowledge for each level of examination based on the results of the study.

Table 7. Recommended Body of Knowledge for the Lean manufacturing Certification Examination

	WEIGHTINGS PER EXAM		
	BRONZE (Tactical)	SILVER (Integrative)	GOLD (Strategic)
I. ENABLERS FOR LEAN	**33.0%**	**31.1%**	**31.4%**
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation 1.1.1.1 Business Vision 1.1.1.2 Business Mission 1.1.1.3 Business Purpose 1.1.1.4 Business Values, Philosophy, Ethics 1.1.1.5 Strategic Business Assessment 1.1.1.6 Strategy Development 1.1.1.7 Business Goals and Objectives 1.1.1.8 Core Competencies 1.1.1.9 Critical Success Factors	1.9%	* 2.4%	* 2.5%
1.1.2. Respect for Humanity and Social Responsibility 1.1.2.1 Schools and Communities 1.1.2.2 Unions 1.1.2.3 Other Stakeholders	1.2%	1.4%	* 2.2%
I. ENABLERS FOR LEAN			
1.1.3. Long and Short-term Planning 1.1.3.1 Hoshin Planning & Policy Deployment 1.1.3.2 Execution and Metrics 1.1.3.3 Project Management	* 2.6%	* 2.4%	* 2.5%
1.1.4. Principles of Lean leadership 1.1.4.1 Go and See 1.1.4.2 Defining Value vs Non-value 1.1.4.3 Identifying Waste 1.1.4.4 Achieving Flow 1.1.4.5 Recognizing Normal vs Abnormal 1.1.4.6 Respect for Humanity	* 4.5% (1.1.4.1 *)	* 3.0%	* 2.5%

	BRONZE (Tactical)	SILVER (Integrative)	GOLD (Strategic)
1.1.5. Lean Corporate Culture	* 3.7% (1.1.5.1*, 1.1.5.2 *)	* 3.0%	* 2.5%
1.1.5.1 Value Stream Mapping			
1.1.5.2 Kaizen Blitz Events			
1.1.5.3 Continuous Improvement & Change			
1.1.5.4 Communication of Business Values, Philosophy, Ethics			
1.1.5.5 Change & knowledge management systems			
1.1.5.6 Resource Standards & Measures for Business Results			
1.2.1. Principles of Empowerment	* 2.7%	* 2.5%	* 2.5%
1.2.1.1 Communication			
1.2.1.2 Delegation			
1.2.1.3 Recognition			
1.2.1.4 Rewards			
1.2.1.5 Employee Satisfaction & Morale			
1.2.1.6 Employee & Labor Relations			
1.2.2. Employee training and development	* 2.7%	* 2.5%	* 2.5%
1.2.2.1 Instructional Goals			
1.2.2.2 Skills Assessment			
1.2.2.3 Continuous Learning Strategy			
1.2.2.4 Cross-Training			
1.2.2.5 Classroom and On-the-Job Training			
1.2.2.6 Coaching & Mentoring			
1.2.3. Teamwork	* 3.0%	* 3.0%	* 2.5%
1.2.3.1 Cross-Functional Team Selection & Leadership			
1.2.3.2 Multi-Level Participation			
1.2.3.3 Roles & Responsibilities			
1.2.3.4 Decision-Making Types			
1.2.3.5 Team Dynamics (Storming, norming, etc.)			
1.2.4. Suggestion/Feedback/Appraisal System	* 2.6%	* 2.4%	* 2.5%
1.2.4.1 Information Sharing			
1.2.5. Employee Turnover, Absenteeism, and Compensation	1.0%	1.3%	* 2.2%
1.2.6. Ergonomic, clean and safe work environment, and results	* 4.3%	* 3.0%	* 2.5%
1.2.6.1 Environment			
1.2.6.2 Ergonomics			
1.2.6.3 Safety			
Additional Areas from Pre-Delphi			
Motivation Theory	1.7%	* 2.2%	* 2.4%
Socio-technical Systems	1.1%	* 2.0%	* 2.1%

	BRONZE (Tactical)	SILVER (Integrative)	GOLD (Strategic)
II. LEAN CORE OPERATIONS	**35.7%**	**35.8%**	**35.1%**
2.1.1. Operational Vision and Strategy	* 1.9%	* 2.4%	* 2.5%

    2.1.1.1 Operation Processes Vision, Mission, Strategy & Goals
    2.1.1.2 Lean Principles in Strategy
    2.1.1.3 Empowerment in Strategy
    2.1.1.4 Operational Alignment with Organizational Vision, Mission, Strategy & Goals

2.2.1 Product Design and Development	* 2.1%	* 2.4%	* 2.5%

    2.2.1.1 Quality Function Deployment
    2.2.1.2 Concurrent Engineering
    2.2.1.3 Variety Reduction
    2.2.1.4 Engineering Changes
    2.2.1.5 Design for Manufacture & Assembly
    2.2.1.6 Design for Product Life Cycle (DFx)
    2.2.1.7 Failure Mode & Effects Analysis (FMEA)
    2.2.1.8 Life Cycle Engineering
    2.2.1.9 Production Process Preparation (3P)
    2.2.1.10 Knowledge Transfer Methods & Practices

2.2.2. Product Market Service	1.2%	* 2.1%	* 2.4%

    2.2.2.1 Customer Feedback & Market Needs Analysis
    2.2.2.2 Customer Specs and Requirements   (2.2.2.2 *)
    2.2.2.3 New market development & current market exploitation
    2.2.2.4 E-commerce systems
    2.2.2.5 Benchmarking

II. LEAN CORE OPERATIONS

2.3.1. Suppliers	2.2%	* 2.4%	* 2.5%

    2.3.1.1 Supplier Development Processes
    2.3.1.2 Supplier Certification
    2.3.1.3 Supplier Benchmarking
    2.3.1.4 Supplier Satisfaction Measures
    2.3.1.5 Corrective Action System

2.3.2 Customers	* 1.4%	* 2.2%	* 2.5%

    2.3.2.1 Customer Training & Development Processes
    2.3.2.2 Customer Selection Focus
    2.3.2.3 Demand Load Leveling   (2.3.2.3 *,
    2.3.2.4 Corrective Action System   2.3.2.4 *)

2.3.3. Distribution & Transport Alliances	1.7%	* 2.3%	* 2.4%

    2.3.3.1 Warehousing
    2.3.3.2 Distribution Centers
    2.3.3.3 Cross-Docks
    2.3.3.4 Reverse Logistics
    2.3.3.5 Remanufacturing/ Maintenance, Repair and Overhaul (MRO)
    2.3.3.6 Just-in-Time Alliances
    2.3.3.7 Supplier Managed Inventory Systems

	BRONZE (Tactical)	SILVER (Integrative)	GOLD (Strategic)
2.4.1. Systematic identification and elimination of waste	* 4.4%	* 3.0%	* 2.5%
2.4.1.1 Waste Identification and elimination of waste			
2.4.1.2 Value Stream Mapping			
2.4.1.3 Value Analysis			
2.4.1.4 5S Standards & Discipline			
2.4.1.5 Visual Workplace			
2.4.1.6 Kaizen Blitz Events			
2.4.1.7 Mistake Proofing			
2.4.1.8 Source Inspection			
2.4.1.9 Continuous Improvement			
2.4.1.10 Five Why's Problem Solving			
2.4.2. Just-in-Time Operations	* 4.4%	* 3.0%	* 2.5%
2.4.2.1 Takt Time			
2.4.2.2 Material Signals			
2.4.2.3 Pull System			
2.4.2.4 Continuous Flow			
2.4.2.5 Just-in-Time (JIT)			
2.4.2.6 Setup Reduction (SMED)			
2.4.2.7 Total Productive Maintenance (TPM)			
2.4.2.8 Load-Leveling (Heijunka)			

II. LEAN CORE OPERATIONS

	BRONZE (Tactical)	SILVER (Integrative)	GOLD (Strategic)
2.4.3. Cellular & Continuous Flow	* 4.4%	* 3.0%	2.5%
2.4.3.1 Cellular Manufacturing			
2.4.3.2 One Piece Flow			
2.4.3.3 Standard Work			
2.4.3.4 Multi-process Handling			
2.4.3.5 Autonomation			
2.4.3.6 Production Schedule			
2.4.3.7 Bills of Materials			
2.4.3.8 Routings			
2.4.3.9 Flow Analysis Charts			
2.4.4. Lean Tools for Continuous Improvement	* 4.4%	* 3.0%	* 2.5%
2.4.4.1 Plan-Do-Check-Act			
2.4.4.2 Reliability & maintainability			
2.4.4.3 Root Cause & Corrective Action			
2.4.4.4 Flow Charting			
2.4.4.5 Pareto			
2.4.4.6 Cause & effect Diagrams			
2.4.4.7 Check Sheets			
2.4.4.8 Histograms			
2.4.4.9 Scatter & Concentration Diagrams			
2.4.4.10 Control Charts			
2.4.4.11 Problem Solving Storyboards			

	BRONZE (Tactical)	SILVER (Integrative)	GOLD (Strategic)
Additional Areas from Pre-Delphi			
Six Sigma/Problem Solving Techniques *(merge with 2.4.4)*	1.8%	2.2%	* 2.2%
Quantitative Decision-Making Techniques *(merge with 2.4.4)*	1.7%	2.2%	* 2.3%
Simulation Technique	1.1%	1.8%	1.8%
Optimization Techniques	1.1%	1.5%	1.8%
Facilities Design and Layout	1.9%	2.4%	* 2.3%
III. BUSINESS CORE OPERATIONS-SUPPORT FUNCTIONS	**9.1%**	**11.1%**	**12.0%**
3.1.1 Administrative Vision & Strategy	* 2.6%	* 2.5%	* 2.5%
3.1.1.1 Application of Lean principles & techniques			
3.1.1.2 Focus on value adds & waste identification & elimination			
3.1.1.3 Commitment to Continuous Improvement			
3.1.1.4 Business operations improvement metrics			
3.1.2. Alignment & Systematic Business & Service Process Design	1.7%	* 2.3%	* 2.5%
3.1.2.1 Finance & Accounting: Measurement & control systems,etc			
3.1.2.2 Human Resources: Alignment of selection, development, teamwork, performance feedback & discipline, compensation & rewards, etc.			
3.1.2.3 Materials Management:Inventory Control,planning&scheduling,logistics, etc			
3.1.2.4 Information Technology:Appropriate alignment with process changes, accessibility,etc			
3.1.2.5 Sales&Marketing:Alignment of sales&operations planning&execution,etc			
3.1.2.6 Quality Assurance: Regulation & certification, inspection rationale, etc			
3.2.1.7 Process & Manufacturing Engineering: System for engineering changes, concurrent process, etc			
3.2.1.8 Legal & Regulatory: Alignment with core lean thinking, etc			
Additional Areas from Pre-Delphi			
Supply Chain Logistics	1.8%	* 2.3%	* 2.4%
Lean Accounting	1.3%	* 2.1%	* 2.4%
Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	1.7%	2.0%	2.2%
IV. QUALITY, COST & DELIVERY MEASURES-	**15.5%**	**12.8%**	**11.8%**
4.1.1 Quality Results	* 4.3%	* 3.0%	* 2.4%
4.1.1.1 Rework			
4.1.1.2 Customer PPM Rejects			
4.1.1.3 First Pass Yield			
4.1.1.4 Scrap			
4.1.1.5 Process Variation			
4.1.1.6 Cost of Quality			
4.1.1.7 Warranty Costs			

	BRONZE (Tactical)	SILVER (Integrative)	GOLD (Strategic)
4.2.1 Cost & Productivity Results	* 4.3%	* 3.0%	* 2.5%
4.2.1.1 Inventory Turns			
4.2.1.2 Record Accuracy			
4.2.1.3 Cycle Time, Takt Time and Throughput Time			
4.2.1.4 Operational Equipment Effectiveness (OEE)			
4.2.1.5 Labor Value-Add			
4.2.1.6 Product Cost Reduction			
4.2.1.7 Changeover			
4.2.1.8 Resource Utilization			
4.2.1.9 Energy Efficiency			
4.2.1.10 Performance to Load Leveling			
4.3.1 Delivery and Customer Service Measurement	* 3.3%	* 2.9%	* 2.5%
4.3.1.1 Line-Items Delivered On-Time to Customer Requirement			
4.3.1.2 Complete Orders Delivered On-Time to Customer Requirements			
4.3.1.4 Premium Freight			
4.3.1.5 Mistakes in Shipment			
4.3.1.6 Warranty Response, Service, etc.			
Additional Areas from Pre-Delphi			
International Organization for Standardization (ISO) and Lean *(Merge ISO and QMS)*	1.7%	1.8%	* 2.2%
Quality Management System (QMS) *(Merge ISO and QMS)*	1.9%	2.2%	* 2.3%
V. BUSINESS RESULTS	**6.7%**	**9.1%**	**9.7%**
5.1.1 Customer Satisfaction Results	1.9%	* 2.3%	* 2.4%
5.1.1.1 Market Share			
5.1.1.2 Reorder Rate			
5.1.1.3 Customer Survey Results			
5.1.1.4 Customer Audit Results			
5.1.1.5 Other Customer Feedback			
5.1.1.6 Value/Improvement Analysis			
5.1.1.7 Customer Retention			
5.1.1.8 Customer Awards			
5.2.1. Profitability Measurement	* 1.4%	* 2.2%	* 2.4%
5.2.1.1 Operating Income on Sales & Assets			
5.2.1.2 Operating Income on Space			
5.2.1.3 Fixed & Variable Costs			
5.2.1.4 Cash Flow			
5.2.1.5 Value Stream Profitability			
Additional Areas from Pre-Delphi			
Lean Business Metrics *(Include under Lean Accounting)*	2.1%	* 2.4%	* 2.4%
Total Supply Chain Cost *(Include under Lean Accounting)*	1.2%	* 2.2%	* 2.4%

Note: * indicates the Delphi panel members suggested that these competency areas are necessary to be included on the certification exam

In addition to the above percentage of importance, based on the Delphi expert's comments, the following modifications are recommended to the lean body of knowledge:

8. Change the title of 1.1.2 Respect for Humanity and Social Responsibility to "Social Responsibility".
9. Under 1.1.4 Principles of Lean Leadership, add Motivation theory.
10. Competency 1.1.5 Lean corporate culture can be changed to "Lean tools, techniques, and culture" so that the title is consistent with the sub-competencies listed.
11. Include the additional area suggested – "Socio-technical Systems" under 1.2.1 Principles of Empowerment.
12. The additional competency areas suggested – "Six Sigma" and "Quantitative Decision-Making Techniques" can be merged with 2.4.4 Lean tools for continuous improvement.
13. The additional competency areas suggested – "ISO" and "Quality Management Systems" should be merged into one area.
14. The additional competency areas suggested – "Lean Business Matrix" and "Total Supply Chain Cost" should be included under "Lean Accounting".

Test Specifications

Based on the percentage domain distribution obtained from the Delphi study, the number of items covered under every domain that should appear on each level of examination was calculated. Bronze, Silver, and Gold level examinations are set to contain 150 multiple-choice questions to be completed in 3 hour time-frame. The number of items on the test was determined by multiplying the percentage allocated to each domain with the total number of questions in each certification level. Table 8 shows the recommended test blueprint for Bronze, Silver, and Gold level of Lean certification exam. The items below can be adjusted by the SME/AME/Shingo lean certification committee depending upon the percentage of competency areas under each domain which were seemed important or unimportant by the Delphi panel experts.

Table 8

Recommended Test Blueprint for Bronze, Silver, Gold Examination Levels

Domain	Bronze	# of Items on Test	Silver	# of Items on Test	Gold	# of Items on Test
I. Enablers for Lean	33.0%	50	31.1%	47	31.4%	47
II. Lean Core Operations	35.7%	54	35.8%	54	35.1%	53
III. Business Core Operations – Support Functions	9.1%	14	11.1%	17	12.0%	18
IV. Quality, Cost & Delivery Measures	15.5%	23	12.8%	19	11.8%	18
V. Business Results	6.7%	10	9.2%	14	9.7%	15
TOTAL	100%	150	100%	150	100%	150

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SME/AME/SHINGO LEAN CERTIFICATION ROLE DELINEATION STUDY
Results of Round Three Delphi

<u>Please rate or answer the following three items after you have completed rest of the survey:</u>

(5 – Very High to 1- Very Low)

5	4	3	2	1

1. How important are the results of this study (establishing/validating the body of knowledge for the discipline) to the field of Lean manufacturing?

☐	■	☐	☐	☐
36%	*57%*	2%	3%	2%

2. Please rate the overall quality of this study.

☐	■	☐	☐	☐
32%	*51%*	15%	2%	0%

3. Please provide any additional comments you may have regarding the importance and/or quality of this study, and any suggestions you may have for possible improvement.

- By utilizing practicing professionals to develop the BOK, the result should yield content that is consistent with the needs of industry. I applaud your approach and my only idea for improvement may be to drop the third round; it seemed unnecessary as most respondents had solidified their thoughts by the second round.
- This study was well developed and was very comprehensive. This is a good model for overall business planning and execution.
- This study is an important step in validating BOK. I don't know how influential the survey group is or how willing they are to use your findings. Good luck on your paper.
- My interest in this survey/study has greatly increased since my professional developmental goal for this year is to obtain a Lean certification!!
- Paper copy was helpful (vs. on-line) because I did most responses on airplanes without my laptop. Not clear how responses will be used. Need bigger envelopes to return Reponses in.
- A weakness in the Delphi technique is that individual opinions are not often heard. I feel that the Comments sections have adequately addressed this issue; as long as the comments are integrated into the final results (Are they? How are they?). I would have liked to see the option to 'break out' or stratify elements from categories and vote on the individual elements - again, the Comments section was used for this in some cases. I would also suggest the use of colors or indicators if the respondent forgot to vote or voted for two different Importance levels for an element.
- I personally believe that to move from one level to the next there needs to be a "Dwell Time" in each step in which the candidates need to show that they are making progress or actually performing what they say and not just studying the answers.
- Better done online…
- Personally, the email version was easier to deal with than the mailed-copy version… but that's just me.
- I feel the study was prepared very well and complete.
- I admire the thoroughness of the process by three passes at the same material seems redundant.
- It is tedious and somewhat repetitive, makes it easy to lose focus..
- The style of the survey is very hard to work with. Unless my computer is not set up to meet the program you are using I had difficulty trying to fill it in sometimes and the page size is such that it does not fit on a 15 inch screen. Also a number of questions were redundant or repetitive.
- There does not seem to be much differentiation between the silver and gold criteria. Am I missing something?

SME/AME/SHINGO LEAN CERTIFICATION ROLE DELINEATION STUDY
Results of Round Three Delphi

- The Study is the most comprehensive that I have ever seen in my career. I hope that it will serve to standardize and further Lean principles beyond the current narrow minded focus of cost cutting... .
- I am concerned about the six sigma role/or lack of in this study. I have found that in order to sustain the improvements in the value stream you have to understand process capability, mean to failure, first pass yield, and standard deviation. You have to present a stable process/or environment to obtain and sustain the speed of lean. You must be able to use both tools to obtain world class satisfaction. I believe this is lacking in TQM (Lean/six sigma together).
- To #2 above: Forced convergence appears more important than meaning, which is a concern.
 To #1 above: Lean knowledge is not static, therefore as establish body of knowledge is wrong as soon as it is created. Furthermore, know-how can't be measured the same way knowledge/information is. Also: Either Bronze = Tactical stuff; Silver= Integrative and Gold = Strategic OR Silver = Bronze + More stuff and Gold = Silver+Bronze+More stuff; it can't be both, but clearly these results make it seem that way.
- The idea to have a lean certification is very good; however, I think the fundamental purpose of lean has been missed. I don't see how this study has answered, or even considered, basic questions such as: who would want certification? How would they use it? How would it set them apart from a non-certified person? In most manufacturing environments, the lean champion is working with shop-floor employees, trying to change their perspective. Degrees or certifications don't mean much there. The lean philosophy of "Go, do" has been completely lost. Any practicing change agent doesn't have time to prepare for and take these tests. They are too busy implementing and focusing on improvement - not their credentials.
- Somebody had to do this for us to know where to start.
- Just a suggestion: this form allows the user to check all possible answer for one question, for instance the "necessary for the certification exam" you can check "yes" and "no" box at the same time. I know that most of the people involved will take care of this, but a "poka joke" (like using option buttons instead of checkboxes) will be helpful.
- I think the idea of certification is good especially at the Bronze and Silver levels. I agree with most of the comments about redundancy. I think the exams should get progressively more strategic in each competency so that there is no repeating information; each level should build on the one prior. Not much here on culture and how to change it. Focused more on the mechanisms than the philosophy. Overall, I think you are on the right track but the real value will be the depth of the curriculum and the actual application of principles to specific problems/situations to demonstrate competency, otherwise it will be a lot of knowledge that won't be applied.
- You have done a good job on the survey. The problem is that the body of knowledge is too fragmented. Sometimes it is too fine, sometimes too coarse.
- None!
- More work required in standardizing terminology, tools, and methods. The lack of clear definition of terms causes confusion and conflict.
- Please keep in mind, the reason we do lean is to get business results, not to get a certificate that someone passed a written test. I am much more interested in someone who has actually implemented lean tools/techniques and realized sustainable results than I am in someone who is "certified". Bottom line = Results. That is what moves lean efforts formed and makes believers out of people. Not someone's certificate.
- It might have been interesting to have a blog or forum to discuss some of the suggested additions that did not make it, some of the ways the BOK 'mixes' the levels for example - we never talked about splitting out the ones are that not applicable so a person reading the BOK to study knows that X or Y is not in Bronze questions. Overall and interesting process that helped me learn the BOK and think through what the testing and the certification is all about.

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- I think it might have been worthwhile to do this on a collaborative sight such as a Wiki page so that the approach could have been more collaborative. Another option would have been to have a couple of Video teleconferences or a face-to-face meeting. Although that might have been prohibitively expense for what was desired, I know that many times I scratched my head and wondered why someone thought something should have either been on the exam or covered at a certain level and I disagreed, but I wondered what their opinion was, since it was often not reflected in any comments. Additionally, I don't think we ever agreed in the beginning what the specific goal of this effort is--if we had, it might have influenced my opinion on certain areas. I think there is a bit of differing perspective from all of us on the purpose of this, and although some of that will always exist, there might have been a bit more focus and agreement on things. I think you all will have a tough job agreeing on what will finally comprise an exam since it seems we want an awful lot to be included, and if there is not a good transition between the exams, people will get very frustrated with the process and required time and involvement. Thanks for letting me participate.

- The study is an important step toward formalizing training and accreditation in the principles and practices of Lean Manufacturing. Most of us have become involved in Lean Manufacturing through individual company training and initiatives, driven by senior management vision. Results have been good, but always capable of further improvement. More formal training will raise the profile of Lean Manufacturing, hopefully to the extent that senior executives who have not been exposed to the philosophies and approaches to Lean will become more aware / committed to this as the strategic way forward in the global economy that is the way of the modern world. I have been involved in Lean approaches in large companies with high volume products in a narrow market (automotive), and now at a mid-size privately owned contract manufacturer with low to high volumes over a wide range of customers and market segments: the approaches to Lean are more challenging in the latter field, but equally vital, and a nationally recognized system of accrediting talent for Lean would be an asset in raising the profile of Lean Manufacturing as a desirable goal for employee training.

- I believe by having a breadth of people participating from various industries and professions aids in developing an unbiased view of Lean and Lean Certification expectations. Congratulations on taking this on, publishing the results, etc.

- Very good study about Lean Manufacturing. But in 3 parts spread over 6 month is too long.

-As a Lean practitioner over the past 6 years, not having a valid certificate demonstrating proficiency in Lean is a drawback. The industry needs an effective method to document and certify individuals, and this study will enable a robust standard to be set.

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	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important		

I. ENABLERS FOR LEAN

	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	☐	☐	■	☐	☐	☐	■	☐	■	☐	☐	☐	■	☐	■	☐	☐	☐	☐	■	☐
	0%	16%	63%	21%	0%	16%	84%	3%	97%	0%	0%	0%	98%	2%	100%	0%	0%	0%	0%	100%	0%

1.1.1.1 Business Vision
1.1.1.2 Business Mission
1.1.1.3 Business Purpose
1.1.1.4 Business Values, Philosophy, Ethics
1.1.1.5 Strategic Business Assessment
1.1.1.6 Strategy Development
1.1.1.7 Business Goals and Objectives
1.1.1.8 Core Competencies
1.1.1.9 Critical Success Factors

BRONZE Comments: - *Awareness & goals/objective.*
- *All company need vision.*
- *Do not need much depth, but everyone should know how Lean fits into the business--understanding of the business vision, mission and purpose and how Lean is an essential element.*
- *At all three levels candidates must be aware of the Business mission. At the bronze level the candidate needs to know what the intense of the business are. They also need to know what the business beams as excess , being aware of these factors is necessary in developing any plans and actions for lean manufacturing.*
- *Only a need to know.*
- *I find it is very important for everyone to know the strategic business goals. It provides a foundation to prioritize the work load at every person's level.*
- *Even at the tactical level knowledge of the business vision mission, etc are required to succeed. Why North American companies do not succeed as well is because many see lean as something for manufacturing people only and not for whole business enterprise.*

SILVER Comments: - *Should be involved in process.*
- *All company need vision.*
- *The silver level candidate needs to be able to take the business values and philosophy and form goals and objectives not only for his level but also for the bronze level .*

GOLD Comments: - *Critical component.*
- *All company need vision.*
- *Of course this is important but does it have a place on a lean certification exam?*
- *At gold level the candidate needs to be intimately aware of all aspects of developing and implementing business vision mission value strategies and especially resource allocation . This individual must provide guidance to all other levels .*
- *Definite for a complete understanding .*

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1.1.2. Respect for Humanity and Social Responsibility	4 3 2 **1** 0 ☐ ☐ ☐ ■ ☐	Yes **No** ☐ ■	4 3 **2** 1 0 ☐ ☐ ■ ☐ ☐	Yes **No** ☐ ■	**4** 3 2 1 0 ■ ☐ ☐ ☐ ☐	**Yes** No ■ ☐
1.1.2.1 Schools and Communities	0% 5% 29% **55%** 11%	9% **91%**	6% 17% **61%** 16% 0%	26% **74%**	**50%** 43% 7% 0% 0%	**94%** 6%
1.1.2.2 Unions 1.1.2.3 Other Stakeholders	**Comments:** - N/A - If we don't have this we are wasting our time. - Must be good to the area you are in. - I am not sure we fully understand what this section is about in terms of testing… but it is mostly a GOLD topic to test. - Candidates at all levels need to be cognizant of all of the different groups that they will be working with . - Lean like good management (which is what it is) is all about treating people		**Comments:** - Moderate exposure at this level. - Must be good to the area you are in.		**Comments:** - This will depend on their position in company more than lean. - Must be good to the area you are in.	
1.1.3. Long and Short-term Planning	4 3 **2** 1 0 ☐ ☐ ■ ☐ ☐	**Yes** No ■ ☐	4 **3** 2 1 0 ☐ ■ ☐ ☐ ☐	**Yes** No ■ ☐	**4** 3 2 1 0 ■ ☐ ☐ ☐ ☐	**Yes** No ■ ☐
1.1.3.1 Hoshin Planning & Policy Deployment	0% 12% **79%** 9% 0%	**86%** 14%	5% **86%** 9% 0% 0%	**98%** 2%	**95%** 5% 0% 0% 0%	**100%** 0%
1.1.3.2 Execution and Metrics 1.1.3.3 Project Management	**Comments:** - Metrics covered in IV. Project management not required here. - Awareness. - Awareness of goals and alignment of activities to goals. - Need to understand that these are concepts. - How can anyone in a lean environment with leadership succeed if they do not know planning, evaluation and metrics?		**Comments:** - Involved.		**Comments:** - Critical tasks for success.	

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	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	\multicolumn Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?	

I. ENABLERS FOR LEAN

	B 4	3	2	1	0	Yes	No	S 4	3	2	1	0	Yes	No	G 4	3	2	1	0	Yes	No
1.1.4. Principles of Lean leadership	☑	☐	☐	☐	☐	☑	☐	☑	☐	☐	☐	☐	☑	☐	☑	☐	☐	☐	☐	☑	☐

1.1.4.1 Go and See
1.1.4.2 Defining Value vs. Non-value
1.1.4.3 Identifying Waste
1.1.4.4 Achieving Flow
1.1.4.5 Recognizing Normal vs. Abnormal
1.1.4.6 Respect for Humanity

BRONZE	SILVER	GOLD
96% 4% 0% 0% 0% **100%** 0%	100% 0% 0% 0% 0% **100%** 0%	100% 0% 0% 0% 0% **98%** 2%
Comments: - *Basic need.* - *Go and see.* - *These are at the core of Lean.*	**Comments:** - *Leader.* - *Must know areas of waste.*	**Comments:** - *No need to test same areas thrice.* - *Champion.* - *Must know areas of waste.* - *Not sure if we need to keep testing this.*

	B 4	3	2	1	0	Yes	No	S 4	3	2	1	0	Yes	No	G 4	3	2	1	0	Yes	No
1.1.5. Lean corporate culture	☐	☑	☐	☐	☐	☑	☐	☑	☐	☐	☐	☐	☑	☐	☑	☐	☐	☐	☐	☑	☐

1.1.5.1 Value Stream Mapping
1.1.5.2 Kaizen Blitz Events
1.1.5.3 Continuous Improvement & Change
1.1.5.4 Communication of Business Values, Philosophy, Ethics
1.1.5.5 Change & knowledge management systems
1.1.5.6 Resource Standards & Measures for Business Results

BRONZE	SILVER	GOLD
13% **83%** 4% 0% 0% **96%** 4%	96% 4% 0% 0% 0% **100%** 0%	100% 0% 0% 0% 0% **100%** 0%
Comments: - *.1,.2,.3 only.* - *Basic need.*	**Comments:** - *Leader and teacher.*	**Comments:** - *Champion.*

	B 4	3	2	1	0	Yes	No	S 4	3	2	1	0	Yes	No	G 4	3	2	1	0	Yes	No
1.2.1. Principles of empowerment	☐	☐	☑	☐	☐	☑	☐	☐	☑	☐	☐	☐	☑	☐	☑	☐	☐	☐	☐	☑	☐

1.2.1.1 Communication
1.2.1.2 Delegation
1.2.1.3 Recognition
1.2.1.4 Rewards
1.2.1.5 Employee Satisfaction & Morale
1.2.1.6 Employee & Labor Relations

BRONZE	SILVER	GOLD
5% 19% **67%** 9% 0% **82%** 18%	14% **79%** 7% 0% 0% **98%** 2%	93% 7% 0% 0% 0% **100%** 0%
Comments: - *1 and 6 only.* - *Basic need for success.* - *Must empower people.* - *Only an understanding is required at this level. No execution.* - *Lean is about empowerment If this is not important what is???*	**Comments:** - *Basic need for success.* - *Must empower people.*	**Comments:** - *Must develop and champion process.* - *Must empower people.*

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	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Yes	No	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Yes	No	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Yes	No
1.2.2. Employee training and development	4	3	**2**	1	0	**Yes** ■	No	4	**3**	2	1	0	**Yes** ■	No	**4** ■	3	2	1	0	**Yes** ■	No
1.2.2.1 Instructional Goals	0%	28%	**65%**	7%	0%	**82%**	18%	12%	**84%**	4%	0%	0%	**100%**	0%	93%	7%	0%	0%	0%	**100%**	0%
1.2.2.2 Skills Assessment 1.2.2.3 Continuous Learning Strategy 1.2.2.4 Cross-Training 1.2.2.5 Classroom and On-the-Job Training 1.2.2.6 Coaching & Mentoring	**Comments:** - *Fundamentals and principles.* - *Understanding that lean is all about training, but this area is really better suited for the second level.* - *I find it unbelievable that some people do not consider training important. That tells more than anything else why many North American companies fail to achieve all they can at lean.*							**Comments:** - *Training is a key for success and perfection.*							**Comments:** - *Basic need for reaching perfection.* - *Need to understand how to deploy this for entire entity.*						
1.2.3. Teamwork	4	3	**2**	1	0	**Yes** ■	No	**4** ■	3	2	1	0	**Yes** ■	No	**4** ■	3	2	1	0	**Yes** ■	No
1.2.3.1 Cross-Functional Team Selection & Leadership	5%	34%	**55%**	6%	0%	**92%**	8%	**92%**	4%	4%	0%	0%	**100%**	0%	94%	76%	0%	0%	0%	**100%**	0%
1.2.3.2 Multi-Level Participation 1.2.3.3 Roles & Responsibilities 1.2.3.4 Decision-Making Types 1.2.3.5 Team Dynamics (Storming, norming, etc.)	**Comments:** - *Active member.*							**Comments:** - *Key role player or leader.*							**Comments:** - *No need to test thrice.* - *Leader or champion.*						
1.2.4. Suggestion/Feedback/Appraisal System	4	3	**2**	1	0	**Yes** ■	No	4	**3**	2	1	0	**Yes** ■	No	**4** ■	3	2	1	0	**Yes** ■	No
1.2.4.1 Information Sharing	2%	13%	**75%**	11%	0%	**82%**	18%	9%	**79%**	12%	0%	0%	**96%**	4%	87%	13%	0%	0%	0%	**100%**	0%
	Comments: - *Employee feedback only.* - *Need to know the importance of feedback.* - *Again as with teamwork and training I find it unbelievable that people do not consider these absolutely necessary Do these people not track Toyota and what they do? Without information sharing lean will not succeed as well as it should.*							**Comments:** - *Employee feedback possible appraisals.* - *Need to develop metrics to determine success of application.*							**Comments:** - *Key for future success.*						

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Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination?	BRONZE (Tactical)			SILVER (Integrative)			GOLD (Strategic)		
	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important		Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important		Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important		Necessary for Certification exam?

I. ENABLERS FOR LEAN

	BRONZE (Tactical)				SILVER (Integrative)				GOLD (Strategic)			
1.2.5. Employee Turnover, Absenteeism and Compensation	4 3 2 **1** 0 ☐☐☐■☐	Yes	**No** ■	4 3 **2** 1 0 ☐☐■☐☐	Yes	**No** ■	**4** 3 2 1 0 ■☐☐☐☐	**Yes** ■	No
	2% 2% 17% **67**% 12%	2%	**98%**	2% 12% **72**% 14% 0%	18%	**82%**	**51%** 39% 7% 3% 0%	**91%**	9%
	Comments: - Out of their control. - Turnover/absenteeism hurts companies. - A key metric but one that is subject to so many variables it does not become meaningful sometimes .			**Comments:** - Need to understand affects of. - Awareness of impact.			**Comments:** - Need to understand how to reduce. - Minor compared to planning. - Only required at this level, not the others.		
1.2.6. Ergonomic, clean and safe work environment, and results 1.2.6.1 Environment 1.2.6.2 Ergonomics 1.2.6.3 Safety	*4* 3 2 1 0 ■☐☐☐☐	**Yes** ■	No	*4* 3 2 1 0 ■☐☐☐☐	**Yes** ■	No	*4* 3 2 1 0 ■☐☐☐☐	**Yes** ■	No
	80% 18% 2% 0% 0%	**98%**	2%	95% 5% 0% 0% 0%	**100%**	0%	95% 5% 0% 0% 0%	**100%**	0%
	Comments: - 5S - Safety makes this one for every level.			**Comments:** - 5S			**Comments:** - No need to test thrice. - 5S		

Additional Areas from Pre-Delphi	BRONZE (Tactical)			SILVER (Integrative)			GOLD (Strategic)		
Motivation Theory	4 3 **2** 1 0 ☐☐■☐☐	Yes	**No** ■	4 **3** 2 1 0 ☐■☐☐☐	**Yes** ■	No	*4* 3 2 1 0 ■☐☐☐☐	**Yes** ■	No
	0% 10% **60**% 25% 5%	11%	**89%**	7% **64**% 25% 2% 2%	**86%**	14%	**77%** 21% 0% 0% 2%	**95%**	5%
	Comments: - Teamwork enough. - Not a success factor for this level. - Key lean skill. - Seems to me that if people understand motivational theory they can get them to participate better in lean projects. Otherwise wouldn't they have to resort to the traditional direction?			**Comments:** - Positive attitude. - Can be useful as a tool, but don't see need to test at any level.			**Comments:** - Understanding and implementer.		
Socio-technical Systems	4 3 2 **1** 0 ☐☐☐■☐	Yes	**No** ■	4 **3** 2 1 0 ☐■☐☐☐	**Yes** ■	No	4 **3** 2 1 0 ☐■☐☐☐	**Yes** ■	No
	0% 3% 18% **72**% 7%	6%	**94%**	1% **51**% 46% 2% 0%	**71%**	29%	25% **70**% 3% 2% 0%	**95%**	5%
(An approach to design work that involves the interaction between people & technology at workplace)	**Comments:**			**Comments:** - Function of planning. - Would like to see a sample question on this to better judge.			**Comments:** - Planning and motivation (change management). - Too Vague.		

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Please rate each of the three levels of examinations on the following: **IMPORTANCE.** How important is it for the candidate to possess the competency? **NECESSARY FOR CERTIFICATION.** Should the competency be included in the certification examination? **II. LEAN CORE OPERATIONS**	BRONZE (Tactical)						SILVER (Integrative)						GOLD (Strategic)					
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?
2.1.1. Operational Vision and Strategy	4	3	**2** ☑	1	0	Yes / **No** ☑	4	**3** ☑	2	1	0	**Yes** ☑ / No	**4** ☑	3	2	1	0	**Yes** ☑ / No
2.1.1.1 Operation Processes Vision, Mission, Strategy & Goals	0%	16%	**72%**	12%	0%	11% / **89%**	9%	**79%**	12%	0%	0%	**100%** / 0%	95%	5%	0%	0%	0%	**100%** / 0%
2.1.1.2 Lean Principles in Strategy 2.1.1.3 Empowerment in Strategy 2.1.1.4 Operational Alignment with Organizational Vision, Mission, Strategy & Goals	**Comments:** - *Vision mission and goals.* *- Only a modest understanding required if at all.* *- The most successful companies at lean or any management system push decision making down the organization as far as possible and have flatter organizations. How do these people at all levels succeed when asked to do this if they do not understand these principles?*						**Comments:** - *Key requirement for deployment.*						**Comments:** - *Fundamental.*					
2.2.1 Product Design and Development	4	3	**2** ☑	1	0	Yes / **No** ☑	4	**3** ☑	2	1	0	**Yes** ☑ / No	**4** ☑	3	2	1	0	**Yes** ☑ / No
2.2.1.1 Quality Function Deployment	6%	12%	**63%**	19%	0%	27% / **73%**	12%	**79%**	9%	0%	0%	**96%** / 4%	88%	12%	0%	0%	0%	**100%** / 0%
2.2.1.2 Concurrent Engineering 2.2.1.3 Variety Reduction 2.2.1.4 Engineering Changes 2.2.1.5 Design for Manufacture & Assembly 2.2.1.6 Design for Product Life Cycle (DFx) 2.2.1.7 Failure Mode & Effects Analysis (FMEA) 2.2.1.8 Life Cycle Engineering 2.2.1.9 Production Process Preparation (3P) 2.2.1.10 Knowledge Transfer Methods &	**Comments:** - *These are all tools used by any properly managed organization*						**Comments:** - *Only if design responsible as a team member.* *- Especially the last one… knowledge transfer.* *- Very important on this level.*						**Comments:** - *Team leader.* *- from a conceptual point of view… not specific knowledge of some of the technical topics.* *- Awareness that these tools exist is good, some familiarity of application is also useful, but mastery of these is not necessary for Lean success.* *- Evaluation of the results of the tools used.*					

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2.2.2. Product Market Service	4 3 **2 1** 0 (☑ at 1)	Yes / **No**	4 **3** 2 1 0 (☑ at 3)	**Yes** / No	**4** 3 2 1 0 (☑ at 4)	**Yes** / No
2.2.2.1 Customer Feedback & Market Needs Analysis 2.2.2.2 Customer Specs and Requirements 2.2.2.3 New market development & current market exploitation 2.2.2.4 E-commerce systems 2.2.2.5 Benchmarking	1% 2% 18% **74%** 5%	7% / **93%**	2% **70%** 24% 2% 2%	**78%** / 22%	**77%** 23% 0% 0% 0%	**95%** / 5%
	Comments: - Customer emphasis is important. - At a strategic level how do you succeed if you do not understand or know your market place. There can be no disconnect between sales and manufacturing or all other elements of the organization.		**Comments:** - These are either specific tools or strategic inputs. Important? Yes. Important for lean in this role? I can't see why.		**Comments:** - Strategic renewal = Pruning business.	
2.3.1. Suppliers	4 3 **2** 1 0 (☑ at 2)	Yes / **No**	4 **3** 2 1 0 (☑ at 3)	**Yes** / No	**4** 3 2 1 0 (☑ at 4)	**Yes** / No
2.3.1.1 Supplier Development Processes 2.3.1.2 Supplier Certification 2.3.1.3 Supplier Benchmarking 2.3.1.4 Supplier Satisfaction Measures 2.3.1.5 Corrective Action System	0% 37% **51%** 10% 2%	23% / **77%**	5% **83%** 12% 0% 0%	**96%** / 4%	**91%** 9% 0% 0% 0%	**100%** / 0%
	Comments: - Need to understand for JIT. - Why would a tactical person have to know the systemic and strategic issues here. - Are not suppliers integral to the process?		**Comments:** - JIT.		**Comments:** - JIT.	
2.3.2 Customers	4 3 **2 1** 0 (☑ at 1)	Yes / **No**	4 **3** 2 1 0 (☑ at 3)	**Yes** / No	**4** 3 2 1 0 (☑ at 4)	**Yes** / No
2.3.2.1 Customer Training & Development Processes 2.3.2.2 Customer Selection Focus 2.3.2.3 Demand Load Leveling 2.3.2.4 Corrective Action System	4% 3% 26% **63%** 4%	15% / **85%**	7% **62%** 29% 2% 0%	**91%** / 9%	**88%** 12% 0% 0% 0%	**100%** / 0%
	Comments: - Specialize area.		**Comments:** - Facilitate process. - Corrective action.		**Comments:** - Critical at this level. - Very general concept awareness only.	

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Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination? **II. LEAN CORE OPERATIONS**	BRONZE (Tactical)					Necessary for Certification exam?		SILVER (Integrative)					Necessary for Certification exam?		GOLD (Strategic)					Necessary for Certification exam?	
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important		
2.3.3. Distribution & Transport Alliances	4	3	*2* ☐	1	0	Yes	*No* ■	4	*3* ☐	2	1	0	*Yes* ■	No	*4* ■	3	2	1	0	*Yes* ■	No
2.3.3.1 Warehousing	0%	7%	**63%**	30%	0%	7%	93%	0%	**82%**	18%	0%	0%	91%	9%	**75%**	25%	0%	0%	0%	98%	2%
2.3.3.2 Distribution Centers 2.3.3.3 Cross-Docks 2.3.3.4 Reverse Logistics 2.3.3.6 Just-in-Time Alliances 2.3.3.7 Supplier Managed Inventory Systems	Comments: *- Basic understanding required.*							Comments:							Comments:						
2.4.1. Systematic identification and elimination of waste	*4* ■	3	2	1	0	Yes ■	No	*4* ■	3	2	1	0	Yes ■	No	4 ■	3	2	1	0	Yes ■	No
2.4.1.1 Waste Identification and elimination of waste	**92%**	6%	2%	0%	0%	98%	2%	95%	5%	0%	0%	0%	100%	0%	96%	4%	2%	2%	0%	96%	4%
2.4.1.2 Value Stream Mapping 2.4.1.3 Value Analysis 2.4.1.4 5S Standards & Discipline 2.4.1.5 Visual Workplace 2.4.1.6 Kaizen Blitz Events 2.4.1.7 Mistake Proofing 2.4.1.8 Source Inspection 2.4.1.9 Continuous Improvement 2.4.1.10 Five Why's Problem Solving	Comments: *- Fundamental need. - This is the core of the program. - Essence of Lean. - This is what it is all about. All levels need an in-depth understanding. - The core principle of the Toyota Production system so it must be so for lean.*							Comments: *- This is the core of the program.*							Comments: *- No need to test thrice. - This is the core of the program.*						

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	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important		
2.4.2. Just-in-Time Operations	4 ■	3 ☐	2 ☐	1 ☐	0 ☐	Yes ■	No ☐	4 ■	3 ☐	2 ☐	1 ☐	0 ☐	Yes ■	No ☐	4 ■	3 ☐	2 ☐	1 ☐	0 ☐	Yes ■	No ☐
2.4.2.1 Takt Time	91%	9%	0%	0%	0%	100%	0%	98%	2%	0%	0%	0%	100%	0%	92%	6%	2%	0%	0%	97%	3%
2.4.2.2 Material Signals 2.4.2.3 Pull System 2.4.2.4 Continuous Flow 2.4.2.5 Just-in-Time (JIT) 2.4.2.6 Setup Reduction (SMED) 2.4.2.7 Total Productive Maintenance (TPM) 2.4.2.8 Load-Leveling (Heijunka)	Comments: - Basics. - 2.4.2.1, 2.4.2.2, 2.4.2.3, 2.4.2.4, 2.4.2.5 are essential elements at this level. - Understanding of these processes at all levels.							Comments: - Operational impact.							Comments: - No need to test thrice. - Creation & operation.						
2.4.3. Cellular & Continuous Flow	4 ■	3 ☐	2 ☐	1 ☐	0 ☐	Yes ■	No ☐	4 ■	3 ☐	2 ☐	1 ☐	0 ☐	Yes ■	No ☐	4 ■	3 ☐	2 ☐	1 ☐	0 ☐	Yes ■	No ☐
2.4.3.1 Cellular Manufacturing	93%	7%	0%	0%	0%	100%	0%	98%	2%	0%	0%	0%	100%	0%	91%	7%	0%	2%	0%	98%	2%
2.4.3.2 One Piece Flow 2.4.3.3 Standard Work 2.4.3.4 Multi-process Handling 2.4.3.5 Autonomation 2.4.3.6 Production Schedule 2.4.3.7 Bills of Materials 2.4.3.8 Routings 2.4.3.9 Flow Analysis Charts	Comments: - Fundamental needs. - Understanding of these processes at all levels.							Comments:							Comments: - Primarily only for standard work in non-manufacturing areas. - This is tactical stuff. Why on earth does the strategic person/mindset need to be an expert in production schedules?						

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Please rate each of the three levels of examinations on the following: IMPORTANCE. How important is it for the candidate to possess the competency? NECESSARY FOR CERTIFICATION. Should the competency be included in the certification examination? II. LEAN CORE OPERATIONS	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?		Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important	Necessary for Certification exam?	
2.4.4. Lean Tools for Continuous Improvement	4 ■	3 ☐	2 ☐	1 ☐	0 ☐	Yes ■	No ☐	4 ■	3 ☐	2 ☐	1 ☐	0 ☐	Yes ■	No ☐	4 ■	3 ☐	2 ☐	1 ☐	0 ☐	Yes ■	No ☐
2.4.4.1 Plan-Do-Check-Act	88%	10%	2%	0%	0%	100%	0%	96%	4%	0%	0%	0%	100%	0%	92%	8%	0%	0%	0%	96%	4%
2.4.4.2 Reliability & maintainability 2.4.4.3 Root Cause & Corrective Action 2.4.4.4 Flow Charting 2.4.4.5 Pareto 2.4.4.6 Cause & effect Diagrams 2.4.4.7 Check Sheets 2.4.4.8 Histograms 2.4.4.9 Scatter & Concentration Diagrams 2.4.4.10 Control Charts 2.4.4.11 Problem Solving Storyboards	Comments: - User. - Need to measure to validate understanding. Very applicable at all levels.							Comments: - Creator.							Comments: - No need to test thrice. - Value stream maps- adopt universal method.						
Additional Areas from Pre-Delphi	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
Six Sigma/Problem Solving Techniques	4 ☐	3 ☐	2 ■	1 ☐	0 ☐	Yes ☐	No ■	4 ☐	3 ■	2 ☐	1 ☐	0 ☐	Yes ■	No ☐	4 ■	3 ☐	2 ☐	1 ☐	0 ☐	Yes ■	No ☐
	0%	10%	69%	16%	5%	15%	85%	4%	73%	20%	2%	1%	84%	16%	62%	29%	5%	2%	2%	91%	9%
	Comments: - The core 7 tools cover 95% of problems say Ishikawa. - Awareness, 5 whys. - Some familiarity but not proficiency. - Only an understanding on what it is. - If 6 sigma is the plan of choice for your company or your major customers this becomes more important.							Comments: - No need to test on 100's of these. - Awareness. - This is a "nice to have" but is not necessary.							Comments: - Familiarity only. This is not Six Sigma certification and it takes away from Lean emphasis.						
Quantitative Decision Making Techniques	4 ☐	3 ☐	2 ■	1 ☐	0 ☐	Yes ☐	No ■	4 ☐	3 ■	2 ☐	1 ☐	0 ☐	Yes ■	No ☐	4 ■	3 ☐	2 ☐	1 ☐	0 ☐	Yes ■	No ☐
	2%	5%	66%	23%	4%	15%	85%	5%	73%	20%	0%	2%	80%	20%	73%	22%	4%	0%	2%	92%	8%
	Comments: - The core tools are quantified. - Interpret. - Familiarity but not proficiency! - Only an understanding on what it is.							Comments: - User.							Comments: - Creator. - Why does strategic need to know more about tactical problem solving?						

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II. Additional Areas from Pre-Delphi	BRONZE (Tactical)		SILVER (Integrative)		GOLD (Strategic)	
	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?
Simulation Technique	4 **3** 2 **1** 0	**Yes** **No**	4 **3** 2 1 0	**Yes** No	4 **3** 2 1 0	**Yes** No
	2% 3% 14% 69% 12%	7% **93%**	3% **44%** 42% 9% 2%	**55%** 45%	16% **63%** 14% 5% 2%	**75%** 25%
	Comments: - Lean/Do is best. Too many simulation techniques to evaluate. - Awareness. - Expect familiarity but not proficiency.		**Comments:** - User. - This is a "nice to have" but is not necessary.		**Comments:** - Minor. - This is very specific expertise that should not necessary for Lean certification. Awareness that simulation is a powerful tool, which may be useful is good, but mastery of the tool is unnecessary. - This is a tool that is overlooked. This is a "nice to have" but is not necessary.	
Optimization Techniques	4 3 2 **1** 0	Yes **No**	4 3 **2** 1 0	Yes **No**	4 **3** 2 1 0	**Yes** No
	4% 0% 14% **75%** 7%	6% **94%**	4% 16% **66%** 12% 2%	32% **68%**	12% **60%** 21% 5% 2%	**78%** 22%
	Comments: - Eliminate waste best. Too many other techniques to evaluate. - Some familiarity but not proficiency.		**Comments:**		**Comments:** - Specialized field of expertise. - Lean isn't necessarily about optimization. - This is very specific expertise that should not necessary for Lean certification. Awareness that simulation is a powerful tool, which may be useful is good, but mastery of the tool is unnecessary. - Another tool that can be employed to further understanding.	
Facilities Design and Layout	4 3 **2** 1 0	Yes **No**	4 **3** 2 1 0	**Yes** No	**4** 3 2 1 0	**Yes** No
	0% 11% **74%** 12% 4%	25% **75%**	18% **70%** 10% 0% 2%	**95%** 5%	**75%** 19% 2% 2% 2%	**93%** 7%
	Comments: - Going beyond lean-can guide architects on lean. - Expect more experience. - The basics of facilities design and layout should be considered here. - Is 5S a part of this? It should be.		**Comments:** - Impact.		**Comments:** - Change and impact. - Strategy/strategic not equal factory kept.	

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III. BUSINESS CORE OPERATIONS-SUPPORT FUNCTIONS	BRONZE (Tactical)		SILVER (Integrative)		GOLD (Strategic)	
	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?	Importance	Necessary for Cert. exam?
3.1.1 Administrative Vision & Strategy	4 3 **2** 1 0 ☐ ☐ ■ ☐ ☐	**Yes** ■ No ☐	4 **3** 2 1 0 ☐ ■ ☐ ☐ ☐	**Yes** ■ No ☐	**4** 3 2 1 0 ■ ☐ ☐ ☐ ☐	**Yes** ■ No ☐
3.1.1.1 Application of Lean principles & techniques	2% 12% **79%** 5% 2%	**84**% 16%	10% **88**% 2% 0% 0%	**100**% 0%	**96**% 4% 0% 0% 0%	**100**% 0%
3.1.1.2 Focus on value adds & waste identification & elimination 3.1.1.3 Commitment to Continuous Improvement 3.1.1.4 Business operations improvement metrics	**Comments:** - *Basic principles.* - *Basic understanding required.*		**Comments:** - *User & involved.*		**Comments:** - *Area leader.*	
3.1.2. Alignment & Systematic Business & Service Process Design	4 3 **2** 1 0 ☐ ☐ ■ ☐ ☐	Yes ☐ *No* ■	4 **3** 2 1 0 ☐ ■ ☐ ☐ ☐	**Yes** ■ No ☐	**4** 3 2 1 0 ■ ☐ ☐ ☐ ☐	**Yes** ■ No ☐
3.1.2.1 Finance & Accounting: Measurement & control systems,etc	2% 5% **71**% 20% 2%	6% **94%**	8% **72**% 20% 0% 0%	**95**% 5%	**86**% 14% 0% 2% 0%	**100**% 0%
3.1.2.2 Human Resources: Alignment of selection, development, teamwork, performance feedback & discipline, compensation & rewards, etc. 3.1.2.3 Materials Management:Inventory Control,planning&scheduling,logistics, etc 3.1.2.4 Information Technology:Appropriate alignment with process changes, accessibility,etc 3.1.2.5 Sales&Marketing:Alignment of sales&operations planning&execution,etc 3.1.2.6 Quality Assurance: Regulation & certification, inspection rationale, etc 3.2.1.7 Process & Manufacturing Engineering: System for engineering changes, concurrent 3.2.1.8 Legal & Regulatory: Alignment with core lean thinking, etc	**Comments:** - *Limited HR process QA.*		**Comments:** - *Overall impact.* - *I feel that emphasis of these elements are very important at the integrative level.*		**Comments:**	

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	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No	4	3	2	1	0	Yes	No
Supply Chain Logistics	4%	3%	**75%**	16%	2%	7%	**93%**	5%	**77%**	18%	0%	0%	**91%**	9%	**77%**	23%	0%	0%	0%	**98%**	2%
Comments:																					
— Awareness of impact.								Comments:							Comments:						
Lean Accounting	3%	5%	24%	**60%**	8%	8%	**92%**	6%	**50%**	44%	0%	0%	**78%**	22%	**74%**	24%	2%	0%	0%	**100%**	0%
Comments:								Comments: — User. — Everything that is useful to be familiar with does not need to be on the exam.							Comments: — Creator.						
Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	4%	4%	**64%**	24%	4%	10%	**90%**	4%	33%	**61%**	2%	0%	**83%**	17%	**54%**	40%	4%	2%	0%	**93%**	7%
Comments: — User. —If you have a successful lean program on the order of Toyota MRP/ERP are not required.								Comments: — User. — Only as it supports or interfaces with the Lean effort.							Comments: — Depends on level in the organization. — Comments: Only as it supports or interfaces with the Lean effort.						

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	Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important			Extremely Important	Very Important	Moderately Important	Slightly Important	Not Important		
IV. QUALITY, COST & DELIVERY MEASURES																					
4.1.1 Quality Results	4 ■	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ■	No ☐	4 ■	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ■	No ☐	4 ■	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ■	No ☐
4.1.1.1 Rework	*82%*	16%	2%	0%	0%	*100%*	0%	*91%*	17%	2%	0%	0%	*98%*	2%	*93%*	4%	3%	0%	0%	*94%*	6%
4.1.1.2 Customer PPM Rejects 4.1.1.3 First Pass Yield 4.1.1.4 Scrap 4.1.1.5 Process Variation 4.1.1.6 Cost of Quality 4.1.1.7 Warranty Costs	**Comments:** *- Muda.* *- Six sigma attributes.*							**Comments:** *- Muda.*							**Comments:** *- No need to test thrice.* *- Muda.*						
4.2.1 Cost & Productivity Results	4 ■	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ■	No ☐	4 ■	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ■	No ☐	4 ■	3 ☐	2 ☐	1 ☐	0 ☐	*Yes* ■	No ☐
4.2.1.1 Inventory Turns	*82%*	16%	0%	0%	2%	*98%*	2%	*93%*	7%	0%	0%	0%	*100%*	0%	*93%*	5%	2%	0%	0%	*100%*	0%
4.2.1.2 Record Accuracy 4.2.1.3 Cycle Time, Takt Time and Throughput Time 4.2.1.4 Operational Equipment Effectiveness (OEE) 4.2.1.5 Labor Value-Add 4.2.1.6 Product Cost Reduction 4.2.1.7 Changeover 4.2.1.8 Resource Utilization 4.2.1.9 Energy Efficiency 4.2.1.10 Performance to Load Leveling	**Comments:** *- Muda.* *- Very broad and not all needs to be tested. Recommend only tested area for Bronze is 4213.*							**Comments:** *- Muda.*							**Comments:** *- Muda.*						

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	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important			Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important			Necessary for Certification exam?	Extremely Important / Very Important / Moderately Important / Slightly Important / Not Important			Necessary for Certification exam?
4.3.1 Delivery and Customer Service Measurement	4 **3** 2 1 0 ☐ ■ ☐ ☐ ☐			Yes ■ No ☐	**4** 3 2 1 0 ■ ☐ ☐ ☐ ☐			Yes ■ No ☐	**4** 3 2 1 0 ■ ☐ ☐ ☐ ☐			Yes ■ No ☐
4.3.1.1 Line-Items Delivered On-Time to Customer Requirement	9% **61%** 30% 0% 0%			89% 11%	80% 18% 2% 0% 0%			98% 2%	92% 5% 3% 0% 0%			98% 2%
4.3.1.2 Complete Orders Delivered On-Time to Customer Requirements 4.3.1.4 Premium Freight 4.3.1.5 Mistakes in Shipment 4.3.1.6 Warranty Response, Service, etc.	**Comments:** - *Awareness of impact.* - *Six sigma attributes.* - *Of what use is the system without customers so elements of this are key.*				**Comments:** - *Could lead. Must understand impact.*				**Comments:** - *Driver and leader.*			
Additional Areas from Pre-Delphi	BRONZE (Tactical)				SILVER (Integrative)				GOLD (Strategic)			
International Organization for Standardization (ISO) and Lean	4 3 **2** 1 0 ☐ ☐ ■ ☐ ☐			Yes ☐ **No** ■	4 3 **2** 1 0 ☐ ☐ ■ ☐ ☐			**Yes** ■ No ☐	**4** 3 2 1 0 ■ ☐ ☐ ☐ ☐			Yes ■ No ☐
	3% 5% **68%** 19% 5%			7% 93%	4% 26% **64%** 4% 2%			67% 33%	**50%** 41% 7% 0% 2%			88% 12%
	Comments: - *ISO# lean, often times, as implemented, its contradictory, either way. It does not need to on a lean exam.* - *Vital.*				**Comments:** - *Only test what it is, not methodology to achieve.* - *Vital.* - *Should learn about the relationship, but not be tested on it.*				**Comments:** - *Awareness of fundamentals.* - *Vital.*			
Quality Management System (QMS)	4 3 **2** 1 0 ☐ ☐ ■ ☐ ☐			Yes ☐ **No** ■	4 **3** 2 1 0 ☐ ■ ☐ ☐ ☐			**Yes** ■ No ☐	**4** 3 2 1 0 ■ ☐ ☐ ☐ ☐			Yes ■ No ☐
	5% 8% **68%** 12% 7%			19% 81%	3% **72%** 18% 0% 7%			85% 15%	73% 18% 5% 0% 4%			91% 9%
	Comments: - *Already testing 7 quality core tools + lean principles.* - *QMS is often just a fancy phrase for ISO.*				**Comments:**				**Comments:** - *Awareness of fundamentals.*			

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	Importance (Extremely / Very / Moderately / Slightly / Not Important)	Necessary for Certification exam?	Importance (Extremely / Very / Moderately / Slightly / Not Important)	Necessary for Certification exam?	Importance (Extremely / Very / Moderately / Slightly / Not Important)	Necessary for Certification exam?
5.1.1 Customer Satisfaction Results	4 3 **2** 1 0 (Moderately Important)	Yes **No** (No)	4 **3** 2 1 0 (Very Important)	**Yes** No (Yes)	**4** 3 2 1 0 (Extremely Important)	**Yes** No (Yes)
5.1.1.1 Market Share	0% 20% **59%** 20% 2%	13% **87%**	4% **78%** 18% 0% 0%	**93%** 7%	**85%** 13% 2% 0% 0%	**98%** 2%
5.1.1.2 Reorder Rate 5.1.1.3 Customer Survey Results 5.1.1.4 Customer Audit Results 5.1.1.5 Other Customer Feedback 5.1.1.6 Value/Improvement Analysis 5.1.1.7 Customer Retention 5.1.1.8 Customer Awards	**Comments:** - Interpret results. - Bean counters. A Lean practitioner should be aware of this information but I do not think they should be required to have this competency. Many companies keep this information only at the highest levels of senior mgmt.		**Comments:** - Analyze. - Bean counters. - A Lean practitioner should be aware of this information but I do not think they should be required to have this competency. Many companies keep this information only at the highest levels of senior mgmt.		**Comments:** - Capture and analyze. - Bean counters. - A Lean practitioner should be aware of this information but I do not think they should be required to have this competency. Many companies keep this information only at the highest levels of senior mgmt.	
5.2.1. Profitability Measurement	4 3 2 **1** 0 (Slightly Important)	Yes **No** (No)	4 **3** 2 1 0 (Very Important)	**Yes** No (Yes)	**4** 3 2 1 0 (Extremely Important)	**Yes** No (Yes)
5.2.1.1 Operating Income on Sales & Assets	1% 4% 32% **57%** 6%	19% **81%**	8% **62%** 30% 0% 0%	**88%** 12%	**83%** 17% 0% 0% 0%	**100%** 0%
5.2.1.2 Operating Income on Space 5.2.1.3 Fixed & Variable Costs 5.2.1.4 Cash Flow 5.2.1.5 Value Stream Profitability	**Comments:** - Little impact. - Bean counters. - Tactical needs to understand cause and effect. - A Lean practitioner should be aware of this information but I do not think they should be required to have this competency. Many companies keep this information only at the highest levels of senior mgmt.		**Comments:** - Access is limited. - Bean counters. - A Lean practitioner should be aware of this information but I do not think they should be required to have this competency. Many companies keep this information only at the highest levels of senior mgmt.		**Comments:** - Full exposure and developer. - Bean counters. - A Lean practitioner should be aware of this information but I do not think they should be required to have this competency. Many companies keep this information only at the highest levels of senior mgmt.	

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Additional Areas from Pre-Delphi	BRONZE (Tactical)							SILVER (Integrative)							GOLD (Strategic)						
	4	3	*2*	1	0	Yes	*No*	4	*3*	2	1	0	*Yes*	No	*4*	3	2	1	0	*Yes*	No
Lean Business Metrics	☐	☐	■	☐	☐	☐	■	☐	■	☐	☐	☐	■	☐	■	☐	☐	☐	☐	■	☐
	3%	5%	*82%*	8%	2%	43%	*57%*	10%	*84%*	4%	0%	2%	*97%*	3%	*91%*	7%	0%	0%	2%	*98%*	2%
	Comments: - *Metrics already covered.* - *Interpret results.* - *Need to understand how to read and use the metrics.*							Comments: - *Analyze and impact.*							Comments:						
	4	3	2	*1*	0	Yes	*No*	4	*3*	2	1	0	*Yes*	No	*4*	3	2	1	0	*Yes*	No
Total Supply Chain Cost	☐	☐	☐	■	☐	☐	■	☐	■	☐	☐	☐	■	☐	■	☐	☐	☐	☐	■	☐
	3%	2%	25%	*63%*	7%	6%	*94%*	5%	*70%*	23%	0%	2%	*82%*	18%	*80%*	18%	0%	0%	2%	*98%*	2%
	Comments: - *Supply chain already covered.*							Comments:							Comments: - *Planning then execution.*						

SME/AME/SHINGO LEAN CERTIFICATION ROLE DELINEATION STUDY
Results of Round Three Delphi

Additional Comments if Any:

- If subject was relevant at Bronze, there is a tendency to test same area three times - Bronze, Silver, and Gold. We need to differentiate which subjects are more appropriate for each level in these cases. Otherwise I fear the Gold & Silver will be too biased towards tactical questions.

- I agree with the Round 2 comments about the complexity of the exam process. The bronze levels, more value should be placed on PDCA in the portfolio. I doubt I will ever apply for Gold because of the overwhelming prep time. I also agree with the last comment on Round 2 about the 3 levels building on each other. I don't know if the Silver and Gold levels will be worth the effort. The customer service and responsiveness of SME staff are so bad that I may never bother with Bronze/Silver/Gold again. The concept may be OK, but execution by SME does not follow any lean concepts at all! If ASQ were administering the exam, it wouldn't be so poorly done. Shingo needs to drop AME and SME if they want a professional certification process.

- The more I look at these questionnaires, the less distinction I see between Silver and Gold levels. Additionally, many of the questions deal with very specific techniques of an operations research nature which I should not expect a Lean Expert to have mastered. Nice but not mandatory. A good knowledge of when seek outside help is all that's really necessary. My assessment is Bronze level should be an accomplished Beginner, Gold level an Expert and Silver, someone in between. I really don't see the distinction between Gold and Silver developing here.

- Some of the 2.X and 4.X are so central to Lean that I have gone along with the majority and marked YES for every level even though I am not entirely sure that the Silver and Gold tests need more than touch on these... or they need to test them at the judgment level and not at the knowledge and application levels of question.

- Under 1.2.3.5 Team Dynamics are an important element and should have a higher score under the Bronze Category.

- I think my comments from round 2 are still applicable. I worry that the qualification process will be too detailed and painful. There is not always a need to be tested on something that is useful to be aware of, but one doesn't need to be an expert in. Additionally, some areas such as motivation theory are always good tools to have available in your bag of tricks, but I don't think are necessary to be tested on since they are very subjective.

I look at the 3 levels as building on each other, especially given that one has to take each exam in order before proceeding forward. Given that prerequisite, I don't think the Gold exam for example, should test every area--it would be painfully long. It should only have a sampling of questions from the preceding exams and fill in with the new strategic areas that are only applicable to Gold. The other option would be to make the exams comprehensive for their levels, and not make them with prerequisites. Even though I think the structure and information provided to help people take the different exams are worthwhile, I am not sure if there will be a driving need for me to take the exams. Even though I essentially function at the Gold level in my organization, there would be quite a time and cost involvement in preparing for and taking the exams. I am not sure what the benefit to my organization would be for me to take the Bronze, then the Silver and finally the Gold exams. Clearly the knowledge gained would be useful, but I am already working on that on my own.

- Level One - Bronze should focus on the understanding of the principles with some basic understanding on execution. Level Two- Silver needs to focus on the execution of the principles Level Three - Gold should be more global in design to be used with the execution of other waste elimination strategies or it is redundant with Silver. Questions should evolve to a higher level of understanding for each level and not test over the same information.

- I'm not sure how practical it is to expect someone to go to such deep levels of knowledge in so many categories. For example, simulation is great but I honestly do not see it being applied except in some very mature industries or very large companies with a lot of staff. This is specialized and could be done via a consultant. I don't think it should be required for Lean certification. I think another survey would be helpful in understanding which subjects have been used and the frequency of their use. Additionally, who do you expect will try to be certified? Will it be someone already with a good foundation of engineering or someone totally lacking an engineering foundation?

- A successful lean program has to be integrated throughout the whole organization. This also includes customers, suppliers and other stakeholders. If you do Toyota and other successful practitioners like Lincoln Electric have proven you can succeed well beyond expectations. If you confine it to one area or limit information you will be like Delphi with a very successful lean program on the shop floor but in bankruptcy.

Thank you for your time and effort!

Appendix J

Frequency of Responses, Mean, and

Standard deviation for each Competency Area in the Pre-Delphi Study

	BRONZE							
	LEVEL OF IMPORTANCE							
Competency Areas	**4**	**3**	**2**	**1**	**0**	**Total**	**Mean**	**SD**	**Y%**
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	15	25	46	34	9	129	2.0233	1.10018	46%
1.1.2. Respect for Humanity and Social Responsibility	19	26	29	34	21	129	1.907	1.30768	33%
1.1.3. Long and Short-term Planning	12	26	62	23	6	129	2.1163	0.96524	64%
1.1.4. Principles of Lean leadership	64	40	24	3	1	132	3.2348	0.88118	94%
1.1.5. Lean Corporate Culture	41	41	35	13	1	131	2.82	1.01133	82%
1.2.1. Principles of Empowerment	20	32	48	25	5	130	2.2846	1.06556	60%
1.2.2. Employee training and development	20	33	46	25	5	129	2.2946	1.070	54%
1.2.3. Teamwork	47	44	31	8	1	131	2.9771	0.95648	80%
1.2.4. Suggestion/Feedback/Appraisal System	19	36	45	24	6	130	2.2923	1.074	52%
1.2.5. Employee Turnover, Absenteeism, and Compensation	4	14	46	39	22	125	1.512	1.01295	22%
1.2.6. Ergonomic, clean and safe work environment, and results	56	39	28	7	0	130	3.1077	0.92549	84%
2.1.1. Operational Vision and Strategy	12	21	51	35	10	131	1.92	1.0578	46%
2.2.1 Product Design and Development	22	26	49	26	7	130	2.2308	1.11743	53%
2.3.1. Suppliers	15	26	40	35	14	130	1.9462	1.17012	47%
2.3.2 Customers	18	30	35	39	8	130	2.0846	1.15493	52%
2.3.3. Distribution & Transport Alliances	15	23	46	35	11	130	1.9692	1.12021	46%
2.4.1. Systematic identification and elimination of waste	91	28	0	1	8	126	3.5078	1.02716	96%
2.4.2. Just-in-Time Operations	78	29	17	2	0	126	3.4524	0.78595	94%
2.4.3. Cellular & Continuous Flow	70	35	18	3	0	128	3.37	0.81587	90%
2.4.4. Lean Tools for Continuous Improvement	87	22	17	2	0	128	3.52	0.78354	92%
3.1.1 Administrative Vision & Strategy	17	31	51	23	6	128	2.2344	1.046	53%
3.1.2. Alignment & Systematic Business & Service Process Design	8	18	48	36	19	129	1.6899	1.08108	32%
4.1.1 Quality Results	56	36	28	9	0	129	3.0775	0.96511	86%
4.2.1 Cost & Productivity Results	44	38	35	11	0	128	2.90	0.97883	78%
4.3.1 Delivery and Customer Service Measurement	33	35	30	25	6	129	2.4961	1.19977	64%
5.1.1 Customer Satisfaction Results	11	16	45	37	18	127	1.72	1.1246	29%
5.2.1. Profitability Measurement	12	19	34	40	23	128	1.6641	1.20548	30%

| Competency Areas | SILVER | | | | | | | | |
| | LEVEL OF IMPORTANCE | | | | | | | |
	4	3	2	1	0	Total	Mean	SD	Y%
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	26	70	33	0	0	129	2.9457	0.67673	83%
1.1.2. Respect for Humanity and Social Responsibility	25	35	39	21	9	129	2.36	1.17126	47%
1.1.3. Long and Short-term Planning	33	73	24	1	0	131	3.0534	0.6829	95%
1.1.4. Principles of Lean leadership	75	45	8	0	0	128	3.5234	0.61433	98%
1.1.5. Lean Corporate Culture	74	42	12	0	0	128	3.4844	0.66385	98%
1.2.1. Principles of Empowerment	43	66	20	2	0	131	3.145	0.72454	94%
1.2.2. Employee training and development	45	52	28	3	1	129	3.062	0.85469	91%
1.2.3. Teamwork	74	43	12	2	0	131	3.4427	0.72494	98%
1.2.4. Suggestion/Feedback/Appraisal System	39	55	29	5	0	128	3	0.83241	79%
1.2.5. Employee Turnover, Absenteeism, and Compensation	13	45	37	22	7	124	2.2823	1.05584	49%
1.2.6. Ergonomic, clean and safe work environment, and results	57	45	22	4	1	129	3.19	0.88183	90%
2.1.1. Operational Vision and Strategy	26	61	36	5	0	128	2.8438	0.78808	81%
2.2.1 Product Design and Development	46	56	28	0	0	130	3.1385	0.74453	91%
2.3.1. Suppliers	38	57	28	3	1	127	3.0079	0.83091	87%
2.3.2 Customers	48	51	24	5	1	129	3.0853	0.88416	85%
2.3.3. Distribution & Transport Alliances	32	60	33	3	0	128	2.9453	0.77671	78%
2.4.1. Systematic identification and elimination of waste	94	28	8	0	0	130	3.6615	0.59133	99%
2.4.2. Just-in-Time Operations	91	29	10	0	0	130	3.6231	0.62587	98%
2.4.3. Cellular & Continuous Flow	76	40	11	0	0	127	3.5118	0.62303	97%
2.4.4. Lean Tools for Continuous Improvement	85	30	12	1	0	128	3.5547	0.69654	94%
3.1.1 Administrative Vision & Strategy	36	60	27	5	2	130	2.9462	0.88319	85%
3.1.2. Alignment & Systematic Business & Service Process Design	25	57	40	5	0	127	2.8031	0.79721	73%
4.1.1 Quality Results	65	42	21	2	0	130	3.3077	0.79578	94%
4.2.1 Cost & Productivity Results	70	37	17	1	0	125	3.408	0.75237	97%
4.3.1 Delivery and Customer Service Measurement	51	47	26	5	0	129	3.1163	0.86266	93%
5.1.1 Customer Satisfaction Results	21	56	36	15	0	128	2.6484	0.89258	71%
5.2.1. Profitability Measurement	29	44	40	13	1	127	2.685	0.965	70%

| Competency Areas | GOLD | | | | | | | | |
| | LEVEL OF IMPORTANCE | | | | | | | | |
	4	3	2	1	0	Total	Mean	SD	Y%
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	118	10	2	1		131	3.87	0.437	98%
1.1.2. Respect for Humanity and Social Responsibility	55	36	23	9	6	129	2.969	1.14522	70%
1.1.3. Long and Short-term Planning	91	27	11	1	0	130	3.6	0.67743	95%
1.1.4. Principles of Lean leadership	106	12	11	1	0	130	3.7154	0.6498	93%
1.1.5. Lean Corporate Culture	102	18	5	1	0	126	3.754	0.561	96%
1.2.1. Principles of Empowerment	97	23	9	1	0	130	3.6615	0.64163	92%
1.2.2. Employee training and development	76	32	20	3	0	131	3.3817	0.82702	89%
1.2.3. Teamwork	86	21	20	1	0	128	3.50	0.78369	90%
1.2.4. Suggestion/Feedback/Appraisal System	65	39	17	3	1	125	3.312	0.85587	80%
1.2.5. Employee Turnover, Absenteeism, and Compensation	52	31	29	9	5	126	2.9206	1.13563	70%
1.2.6. Ergonomic, clean and safe work environment, and results	67	27	27	5	2	128	3.1875	1.00197	84%
2.1.1. Operational Vision and Strategy	99	25	7	0	0	131	3.7023	0.56425	98%
2.2.1 Product Design and Development	73	34	17	3	1	128	3.3672	0.85914	90%
2.3.1. Suppliers	81	31	17	0	0	129	3.4961	0.71942	90%
2.3.2 Customers	74	35	19	1	0	129	3.4109	0.76661	88%
2.3.3. Distribution & Transport Alliances	56	47	23	2	0	128	3.2266	0.7958	84%
2.4.1. Systematic identification and elimination of waste	91	20	12	5	0	128	3.5391	0.82197	87%
2.4.2. Just-in-Time Operations	84	20	16	7	1	128	3.40	0.95851	86%
2.4.3. Cellular & Continuous Flow	78	21	21	6	0	126	3.3571	0.92489	86%
2.4.4. Lean Tools for Continuous Improvement	82	17	17	8	1	125	3.368	0.996	89%
3.1.1 Administrative Vision & Strategy	85	32	10	2	0	129	3.5504	0.70688	93%
3.1.2. Alignment & Systematic Business & Service Process Design	87	33	10	0	0	130	3.5923	0.63118	94%
4.1.1 Quality Results	76	32	18	6	0	132	3.3485	0.88227	80%
4.2.1 Cost & Productivity Results	83	28	16	4	0	131	3.4504	0.82475	88%
4.3.1 Delivery and Customer Service Measurement	75	29	22	4	1	131	3.3206	0.91372	89%
5.1.1 Customer Satisfaction Results	87	28	12	3	0	130	3.53	0.75932	93%
5.2.1. Profitability Measurement	90	32	7	1	0	130	3.6231	0.62587	94%

Appendix K

Frequency of Responses, Mean, and

Standard deviation for each Competency Area in Round One Delphi

| Competency Areas | BRONZE | | | | | | | | |
| | LEVEL OF IMPORTANCE | | | | | | | |
	4	3	2	1	0	Total	Mean	SD	Y%
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	3	7	43	18	2	73	1.88	0.781	24.3
1.1.2. Respect for Humanity and Social Responsibility	1	3	20	39	10	73	1.26	0.800	13.5
1.1.3. Long and Short-term Planning	0	17	44	12	0	73	2.07	0.631	85.9
1.1.4. Principles of Lean leadership	58	14	1	1	0	74	3.74	0.550	98.6
1.1.5. Lean Corporate Culture	19	42	13	0	0	74	3.08	0.550	93.2
1.2.1. Principles of Empowerment	3	14	43	11	3	74	2.04	0.818	69.9
1.2.2. Employee training and development	3	22	37	12	1	75	2.22	0.763	62.2
1.2.3. Teamwork	7	25	36	5	0	73	2.47	0.765	86.1
1.2.4. Suggestion/Feedback/Appraisal System	5	16	35	14	2	72	2.11	0.897	57.5
1.2.5. Employee Turnover, Absenteeism, and Compensation	1	9	25	34	4	73	1.58	0.832	13.9
1.2.6. Ergonomic, clean and safe work environment, and results	51	21	1	1	0	74	3.65	0.584	97.3
Motivation Theory	6	9	26	20	10	71	1.73	1.121	25.4
Socio-technical Systems	4	12	20	25	10	71	1.65	1.097	25
2.1.1. Operational Vision and Strategy	1	10	46	16	1	74	1.92	0.678	25.7
2.2.1 Product Design and Development	3	11	43	16	1	74	1.99	0.767	50
2.2.2. Product Market Service	1	6	25	32	9	73	1.42	0.865	24.7
2.3.1. Suppliers	0	8	45	19	2	74	1.8	0.662	25.7
2.3.2 Customers	0	9	23	37	4	73	1.51	0.784	44.4
2.3.3. Distribution & Transport Alliances	1	1	45	25	2	74	1.65	0.629	24.7
2.4.1. Systematic identification and elimination of waste	68	4	1	1	0	74	3.88	0.467	98.6
2.4.2. Just-in-Time Operations	62	12	0	0	0	74	3.84	0.371	98.6
2.4.3. Cellular & Continuous Flow	59	13	1	0	0	73	3.79	0.440	97.3
2.4.4. Lean Tools for Continuous Improvement	61	10	2	0	0	73	3.81	0.461	94.6
Six Sigma/Problem Solving Techniques	10	14	28	15	5	72	2.13	1.113	42.5
Quantitative Decision-Making Techniques	6	14	27	15	7	69	1.96	1.091	39.4
Simulation Technique	2	8	22	26	12	70	1.46	1.003	18.1
Optimization Techniques	1	12	20	22	12	67	1.52	1.035	23.2
Facilities Design and Layout	7	16	29	16	3	71	2.11	1.008	45.1
3.1.1 Administrative Vision & Strategy	4	14	44	10	1	73	2.14	0.769	75.7
3.1.2. Alignment & Systematic Business & Service Process Design	1	4	45	21	2	73	1.74	0.667	13.5
Supply Chain Logistics	3	3	37	25	5	73	1.66	0.844	23.9
Lean Accounting	2	3	25	33	8	71	1.41	0.855	20.8
Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	5	5	29	24	8	71	1.65	1.016	25
4.1.1 Quality Results	53	11	7	1	1	73	3.56	0.833	91.5

	4	3	2	1	0	Total	Mean	SD	Y%
4.2.1 Cost & Productivity Results	45	21	6	1	0	73	3.51	0.710	95.9
4.3.1 Delivery and Customer Service Measurement	11	36	20	6	0	73	2.71	0.825	80.8
International Organization for Standardization (ISO) and Lean	3	9	26	24	8	70	1.64	0.993	25.7
Quality Management System (QMS)	5	11	32	17	3	68	1.97	0.946	39.1
5.1.1 Customer Satisfaction Results	0	5	45	21	2	73	1.73	0.629	13.5
5.2.1. Profitability Measurement	1	4	22	38	7	72	1.36	0.793	11.1
Lean Business Metrics	2	17	32	13	5	69	1.97	0.923	47.9
Total Supply Chain Cost	1	6	26	26	11	70	1.43	0.910	22.5

	SILVER								
	LEVEL OF IMPORTANCE								
Competency Areas	**4**	**3**	**2**	**1**	**0**	**Total**	Mean	SD	Y%
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	7	55	12	0	0	74	2.93	0.506	93.2
1.1.2. Respect for Humanity and Social Responsibility	2	19	40	11	2	74	2.11	0.786	27.4
1.1.3. Long and Short-term Planning	13	57	3	0	0	73	3.14	0.451	100
1.1.4. Principles of Lean leadership	68	6	0	0	0	74	3.92	0.275	100
1.1.5. Lean Corporate Culture	62	11	1	0	0	74	3.82	0.417	98.6
1.2.1. Principles of Empowerment	14	54	6	0	0	74	3.11	0.512	98.6
1.2.2. Employee training and development	15	53	5	0	0	73	3.14	0.509	98.6
1.2.3. Teamwork	56	16	1	0	0	73	3.75	0.465	100
1.2.4. Suggestion/Feedback/Appraisal System	11	48	11	1	0	71	2.97	0.609	91.8
1.2.5. Employee Turnover, Absenteeism, and Compensation	3	30	36	3	0	72	2.46	0.649	35.7
1.2.6. Ergonomic, clean and safe work environment, and results	57	16	1	0	0	74	3.76	0.463	98.6
Motivation Theory	11	31	18	6	5	71	2.52	1.080	69
Socio-technical Systems	10	28	19	10	4	71	2.42	1.078	58.3
2.1.1. Operational Vision and Strategy	9	54	11	0	0	74	2.97	0.523	95.9
2.2.1 Product Design and Development	11	53	10	0	0	74	3.01	0.536	94.6
2.2.2. Product Market Service	5	35	25	9	0	74	2.49	0.798	59.5
2.3.1. Suppliers	6	55	12	1	0	74	2.89	0.538	95.9
2.3.2 Customers	9	44	21	0	0	74	2.84	0.620	93.2
2.3.3. Distribution & Transport Alliances	3	53	16	2	0	74	2.77	0.562	90.5
2.4.1. Systematic identification and elimination of waste	67	6	1	0	0	74	3.89	0.354	100
2.4.2. Just-in-Time Operations	67	7	0	0	0	74	3.91	0.295	100
2.4.3. Cellular & Continuous Flow	66	7	0	0	0	73	3.90	0.296	100
2.4.4. Lean Tools for Continuous Improvement	63	8	2	0	0	73	3.84	0.441	98.6

	4	3	2	1	0	Total	Mean	SD	Y%
Six Sigma/Problem Solving Techniques	20	27	17	4	3	71	2.8	1.050	73.6
Quantitative Decision-Making Techniques	17	32	16	3	1	69	2.88	0.883	71.8
Simulation Technique	8	25	23	11	2	69	2.38	0.987	52.1
Optimization Techniques	11	23	25	7	2	68	2.5	0.985	54.4
Facilities Design and Layout	21	27	17	5	0	70	2.91	0.913	78.6
3.1.1 Administrative Vision & Strategy	14	53	6	0	0	73	3.11	0.515	98.6
3.1.2. Alignment & Systematic Business & Service Process Design	8	49	17	0	0	74	2.88	0.572	87.7
Supply Chain Logistics	7	38	21	4	1	71	2.65	0.795	78.9
Lean Accounting	7	29	28	5	3	72	2.44	0.918	61.1
Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	11	26	29	3	2	71	2.54	0.948	63.9
4.1.1 Quality Results	57	11	4	0	1	73	3.68	0.705	97.2
4.2.1 Cost & Productivity Results	66	6	1	0	0	73	3.89	0.356	98.6
4.3.1 Delivery and Customer Service Measurement	40	29	2	2	0	73	3.47	0.689	95.9
International Organization for Standardization (ISO) and Lean	14	20	23	10	4	71	2.42	1.130	63.4
Quality Management System (QMS)	12	27	24	2	3	68	2.63	0.960	69.6
5.1.1 Customer Satisfaction Results	4	49	21	0	0	74	2.77	0.538	85.1
5.2.1. Profitability Measurement	6	42	22	3	0	73	2.7	0.681	83.6
Lean Business Metrics	15	39	12	1	3	70	2.89	0.910	87.5
Total Supply Chain Cost	8	34	24	3	1	70	2.64	0.799	69

	GOLD								
	LEVEL OF IMPORTANCE								
Competency Areas	**4**	**3**	**2**	**1**	**0**	**Total**	Mean	SD	Y%
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	69	5	0	0	0	74	3.93	0.253	100
1.1.2. Respect for Humanity and Social Responsibility	31	35	5	2	0	73	3.3	0.72	87.7
1.1.3. Long and Short-term Planning	70	3	0	0	0	73	3.96	0.2	100
1.1.4. Principles of Lean leadership	73	0	1	0	0	74	3.97	0.232	97.3
1.1.5. Lean Corporate Culture	68	4	2	0	0	74	3.89	0.391	100
1.2.1. Principles of Empowerment	70	3	1	0	0	74	3.93	0.302	97.3
1.2.2. Employee training and development	61	10	1	1	0	73	3.79	0.526	98.6
1.2.3. Teamwork	61	11	1	0	0	73	3.82	0.42	98.6
1.2.4. Suggestion/Feedback/Appraisal System	58	12	0	1	0	71	3.79	0.505	98.6
1.2.5. Employee Turnover, Absenteeism, and Compensation	39	25	7	1	0	72	3.42	0.727	83.3
1.2.6. Ergonomic, clean and safe work environment, and results	63	9	1	0	1	74	3.8	0.596	93.1
Motivation Theory	36	21	9	2	3	71	3.20	1.05	81.7

Socio-technical Systems	22	26	17	4	2	71	2.87	1.013	72.6
2.1.1. Operational Vision and Strategy	69	5	0	0	0	74	3.93	0.253	100
2.2.1 Product Design and Development	56	16	2	0	0	74	3.73	0.505	95.9
2.2.2. Product Market Service	38	26	10	0	0	74	3.38	0.716	90.4
2.3.1. Suppliers	58	15	0	0	0	73	3.79	0.407	98.6
2.3.2 Customers	57	16	1	0	0	74	3.76	0.463	100
2.3.3. Distribution & Transport Alliances	47	23	3	1	0	74	3.57	0.643	98.6
2.4.1. Systematic identification and elimination of waste	66	7	0	0	0	73	3.90	0.296	94.5
2.4.2. Just-in-Time Operations	62	9	2	0	0	73	3.82	0.452	91.9
2.4.3. Cellular & Continuous Flow	59	10	3	1	0	73	3.74	0.602	93.1
2.4.4. Lean Tools for Continuous Improvement	60	9	3	0	0	72	3.79	0.502	93.2
Six Sigma/Problem Solving Techniques	35	22	7	1	4	69	3.2	1.079	78.9
Quantitative Decision-Making Techniques	38	20	8	2	1	69	3.33	0.902	83.1
Simulation Technique	15	27	16	9	2	69	2.64	1.057	54.9
Optimization Techniques	20	22	19	4	3	68	2.76	1.081	63.8
Facilities Design and Layout	35	18	18	0	0	71	3.24	0.836	80.3
3.1.1 Administrative Vision & Strategy	66	7	0	0	0	73	3.90	0.296	100
3.1.2. Alignment & Systematic Business & Service Process Design	63	11	0	0	0	74	3.85	0.358	98.6
Supply Chain Logistics	35	28	7	1	0	71	3.37	0.722	94.4
Lean Accounting	38	24	9	1	0	72	3.38	0.759	93.1
Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	31	23	14	1	3	72	3.08	1.031	77.8
4.1.1 Quality Results	57	9	5	0	1	72	3.68	0.728	93.1
4.2.1 Cost & Productivity Results	63	7	1	1	0	72	3.83	0.504	97.2
4.3.1 Delivery and Customer Service Measurement	59	11	1	2	0	73	3.74	0.624	93.2
International Organization for Standardization (ISO) and Lean	30	21	12	4	4	71	2.97	1.158	77.5
Quality Management System (QMS)	30	24	9	2	3	68	3.12	1.044	79.7
5.1.1 Customer Satisfaction Results	61	13	0	0	0	74	3.82	0.383	100
5.2.1. Profitability Measurement	65	6	1	1	0	73	3.85	0.491	97.3
Lean Business Metrics	49	16	0	1	3	69	3.55	0.932	91.7
Total Supply Chain Cost	37	27	5	1	1	71	3.38	0.799	94.2

Appendix L

Frequency of Responses, Mean, and

Standard deviation for each Competency Area in Round Two Delphi

Competency Areas	BRONZE								
	LEVEL OF IMPORTANCE								
	4	3	2	1	0	Total	Mean	SD	Y%
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	0	5	42	11	1	59	1.86	0.571	16
1.1.2. Respect for Humanity and Social Responsibility	1	6	12	36	3	58	1.41	0.817	7.1
1.1.3. Long and Short-term Planning	0	8	45	5	0	58	2.05	0.475	86
1.1.4. Principles of Lean leadership	56	4	0	0	0	60	3.93	0.252	100
1.1.5. Lean Corporate Culture	13	40	7	0	0	60	3.10	0.573	95
1.2.1. Principles of Empowerment	1	11	40	8	0	60	2.08	0.619	77
1.2.2. Employee training and development	3	13	34	9	1	60	2.13	0.791	70
1.2.3. Teamwork	4	23	31	1	0	59	2.51	0.653	98
1.2.4. Suggestion/Feedback/Appraisal System	2	15	36	6	1	60	2.18	0.725	77
1.2.5. Employee Turnover, Absenteeism, and Compensation	0	3	12	39	6	60	1.2	0.684	8.3
1.2.6. Ergonomic, clean and safe work environment, and results	46	10	3	1	0	60	3.68	0.651	95
Motivation Theory	3	7	35	13	1	59	1.97	0.787	19
Socio-technical Systems	1	2	12	39	6	60	1.22	0.739	6.8
2.1.1. Operational Vision and Strategy	0	7	41	10	1	59	1.92	0.596	19
2.2.1 Product Design and Development	2	7	39	11	0	59	2	0.67	34
2.2.2. Product Market Service	0	1	17	32	7	57	1.21	0.674	7
2.3.1. Suppliers	0	27	26	4	2	59	2.32	0.753	25
2.3.2 Customers	0	2	19	34	4	59	1.32	0.655	25
2.3.3. Distribution & Transport Alliances	3	38	19	0	0	60	1.73	0.548	10
2.4.1. Systematic identification and elimination of waste	56	4	0	0	0	60	3.93	0.252	100
2.4.2. Just-in-Time Operations	53	7	0	0	0	60	3.88	0.324	100
2.4.3. Cellular & Continuous Flow	54	6	0	0	0	60	3.90	0.303	100
2.4.4. Lean Tools for Continuous Improvement	55	4	1	0	0	60	3.90	0.354	100
Six Sigma/Problem Solving Techniques	5	6	35	11	3	60	1.98	0.911	28
Quantitative Decision-Making Techniques	3	6	33	9	6	57	1.84	0.941	28
Simulation Technique	1	4	13	36	6	60	1.3	0.809	13
Optimization Techniques	0	3	15	36	6	60	1.25	0.704	6.7
Facilities Design and Layout	2	10	37	10	1	60	3.53	0.769	35
3.1.1 Administrative Vision & Strategy	1	12	44	3	0	60	2.18	0.537	80
3.1.2. Alignment & Systematic Business & Service Process Design	0	4	42	13	1	60	1.82	0.567	18
Supply Chain Logistics	0	3	39	17	1	60	1.73	0.578	13

	4	3	2	1	0	Total	Mean	SD	Y%
Lean Accounting	1	3	13	40	3	60	1.32	0.725	6.7
Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	2	1	36	19	2	60	1.7	0.72	13
4.1.1 Quality Results	47	11	2	0	0	60	3.75	0.508	97
4.2.1 Cost & Productivity Results	50	8	2	0	0	60	3.80	0.48	98
4.3.1 Delivery and Customer Service Measurement	8	34	13	5	0	60	2.75	0.795	78
International Organization for Standardization (ISO) and Lean	2	6	30	19	3	60	1.75	0.836	12
Quality Management System (QMS)	2	4	41	10	3	60	1.87	0.747	22
5.1.1 Customer Satisfaction Results	1	3	40	15	1	60	1.80	0.632	15
5.2.1. Profitability Measurement	3	2	14	37	4	60	1.38	0.865	15
Lean Business Metrics	4	6	42	6	1	59	2.10	0.736	44
Total Supply Chain Cost	3	14	39	0	4	60	1.32	0.813	8.3

	SILVER								
	LEVEL OF IMPORTANCE								
Competency Areas	**4**	**3**	**2**	**1**	**0**	**Total**	**Mean**	**SD**	**Y%**
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	3	49	7	0	0	59	2.93	0.41	100
1.1.2. Respect for Humanity and Social Responsibility	4	10	38	5	0	57	2.23	0.71	25
1.1.3. Long and Short-term Planning	8	48	2	0	0	58	3.1	0.41	100
1.1.4. Principles of Lean leadership	58	2	0	0	0	60	3.97	0.18	100
1.1.5. Lean Corporate Culture	53	7	0	0	0	60	3.88	0.32	100
1.2.1. Principles of Empowerment	9	48	3	0	0	60	3.1	0.44	97
1.2.2. Employee training and development	7	49	4	0	0	60	3.05	0.43	98
1.2.3. Teamwork	52	6	1	0	0	59	3.86	0.39	100
1.2.4. Suggestion/Feedback/Appraisal System	8	46	5	1	0	60	3.02	0.54	98
1.2.5. Employee Turnover, Absenteeism, and Compensation	1	13	41	5	0	60	2.17	0.59	27
1.2.6. Ergonomic, clean and safe work environment, and results	55	4	1	0	0	60	3.90	0.35	100
Motivation Theory	6	40	13	0	0	59	2.88	0.56	85
Socio-technical Systems	3	30	26	1	0	60	2.58	0.62	68
2.1.1. Operational Vision and Strategy	6	46	6	1	0	59	2.97	0.52	97
2.2.1 Product Design and Development	7	46	6	0	0	59	3.02	0.47	100
2.2.2. Product Market Service	2	29	26	0	0	57	2.58	0.57	67
2.3.1. Suppliers	3	51	4	1	0	59	2.95	0.43	97

2.3.2 Customers	5	42	11	1	0	59	2.86	0.57	93
2.3.3. Distribution & Transport Alliances	1	44	15	0	0	60	2.77	0.47	93
2.4.1. Systematic identification and elimination of waste	57	3	0	0	0	60	3.95	0.22	100
2.4.2. Just-in-Time Operations	58	2	0	0	0	60	3.97	0.18	100
2.4.3. Cellular & Continuous Flow	58	2	0	0	0	60	3.97	0.18	100
2.4.4. Lean Tools for Continuous Improvement	58	2	0	0	0	60	3.97	0.18	100
Six Sigma/Problem Solving Techniques	9	34	13	2	2	60	2.77	0.87	80
Quantitative Decision-Making Techniques	8	31	14	1	3	57	2.70	0.93	79
Simulation Technique	2	29	21	6	2	60	2.38	0.85	58
Optimization Techniques	3	13	35	8	1	60	2.15	0.78	48
Facilities Design and Layout	12	39	7	1	1	60	2.18	0.54	85
3.1.1 Administrative Vision & Strategy	10	48	2	0	0	60	3.13	0.43	98
3.1.2. Alignment & Systematic Business & Service Process Design	7	46	6	1	0	60	2.98	0.54	92
Supply Chain Logistics	5	42	13	0	0	60	2.87	0.536	90
Lean Accounting	2	33	23	2	0	60	2.58	0.62	78
Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	4	19	33	2	2	60	2.35	0.8	70
4.1.1 Quality Results	51	7	2	0	0	60	3.82	0.47	100
4.2.1 Cost & Productivity Results	57	3	0	0	0	60	3.95	0.22	100
4.3.1 Delivery and Customer Service Measurement	42	17	1	0	0	60	3.68	0.5	98
International Organization for Standardization (ISO) and Lean	2	18	36	3	1	60	2.28	0.69	60
Quality Management System (QMS)	3	32	21	1	3	60	2.52	0.83	68
5.1.1 Customer Satisfaction Results	2	45	13	0	0	60	2.82	0.47	90
5.2.1. Profitability Measurement	3	38	16	2	1	60	2.67	0.705	87
Lean Business Metrics	8	46	4	0	1	59	3.02	0.6	95
Total Supply Chain Cost	3	40	14	3	0	60	2.72	0.64	78

Competency Areas	4	3	2	1	0	Total	Mean	SD	Y%
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	58	1	0	0	0	59	3.98	0.130	100
1.1.2. Respect for Humanity and Social Responsibility	29	24	4	0	0	57	3.44	0.63	95
1.1.3. Long and Short-term Planning	56	2	0	0	0	58	3.97	0.18	100
1.1.4. Principles of Lean leadership	58	0	1	1	0	60	3.92	0.46	95
1.1.5. Lean Corporate Culture	59	1	0	0	0	60	3.98	0.129	100
1.2.1. Principles of Empowerment	55	3	1	1	0	60	3.87	0.5	97
1.2.2. Employee training and development	52	6	1	1	0	60	3.82	0.54	97
1.2.3. Teamwork	54	4	1	0	0	59	3.90	0.36	98
1.2.4. Suggestion/Feedback/Appraisal System	54	5	1	0	0	60	3.88	0.37	98
1.2.5. Employee Turnover, Absenteeism, and Compensation	34	23	1	2	0	60	3.48	0.7	93
1.2.6. Ergonomic, clean and safe work environment, and results	56	2	1	1	0	60	3.88	0.49	98
Motivation Theory	44	13	2	0	0	59	3.71	0.53	90
Socio-technical Systems	18	31	11	0	0	60	3.12	0.69	78
2.1.1. Operational Vision and Strategy	55	3	1	0	0	59	3.92	0.34	100
2.2.1 Product Design and Development	51	8	0	0	0	59	3.86	0.35	100
2.2.2. Product Market Service	40	16	1	0	0	57	3.68	0.51	98
2.3.1. Suppliers	52	5	2	0	0	59	3.85	0.45	100
2.3.2 Customers	52	7	0	0	0	59	3.88	0.33	100
2.3.3. Distribution & Transport Alliances	44	16	0	0	0	60	3.73	0.45	100
2.4.1. Systematic identification and elimination of waste	56	2	1	1	0	60	3.88	0.49	93
2.4.2. Just-in-Time Operations	55	4	1	0	0	60	3.90	0.35	97
2.4.3. Cellular & Continuous Flow	52	6	0	1	1	60	3.78	0.69	92
2.4.4. Lean Tools for Continuous Improvement	54	4	1	1	0	60	3.83	0.615	92
Six Sigma/Problem Solving Techniques	34	18	4	1	2	59	3.47	1.19	87
Quantitative Decision-Making Techniques	35	16	2	1	3	57	3.39	1.03	86
Simulation Technique	9	35	13	1	2	60	2.80	0.84	72
Optimization Techniques	13	35	8	3	1	60	2.93	0.84	78
Facilities Design and Layout	38	19	1	1	1	60	3.13	0.43	97
3.1.1 Administrative Vision & Strategy	55	5	0	0	0	60	3.92	0.28	100

3.1.2. Alignment & Systematic Business & Service Process Design	53	6	0	1	0	60	3.85	0.48	98
Supply Chain Logistics	45	11	4	0	0	60	3.68	0.596	98
Lean Accounting	42	16	0	2	0	60	3.63	0.66	97
Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	31	21	4	1	3	60	3.27	1.02	88
4.1.1 Quality Results	58	2	0	0	0	60	3.97	0.18	97
4.2.1 Cost & Productivity Results	58	1	1	0	0	60	3.95	0.29	98
4.3.1 Delivery and Customer Service Measurement	55	3	2	0	0	60	3.88	0.42	95
International Organization for Standardization (ISO) and Lean	29	19	10	1	1	60	3.23	0.91	87
Quality Management System (QMS)	34	19	4	0	3	60	3.35	0.99	83
5.1.1 Customer Satisfaction Results	48	11	1	0	0	60	3.78	0.45	97
5.2.1. Profitability Measurement	18	11	0	0	1	30	3.75	0.63	98
Lean Business Metrics	53	5	0	0	1	59	3.85	0.58	97
Total Supply Chain Cost	48	10	1	1	0	60	3.75	0.57	98

Appendix M

Frequency of Responses, Mean, and

Standard deviation for each Competency Area in Round Three Delphi

Competency Areas	BRONZE								
	LEVEL OF IMPORTANCE								
	4	3	2	1	0	Total	Mean	SD	Y%
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	0	9	36	12	0	57	1.95	0.61	15.8
1.1.2. Respect for Humanity and Social Responsibility		3	16	31	6	56	1.29	0.731	9.1
1.1.3. Long and Short-term Planning	0	8	43	6	0	57	2.04	0.499	81.5
1.1.4. Principles of Lean leadership	54	2	0	0	0	56	3.96	0.187	100
1.1.5. Lean Corporate Culture	7	44	2	0	0	53	3.09	0.405	96.2
1.2.1. Principles of Empowerment	3	11	38	5	0	57	2.21	0.674	82.1
1.2.2. Employee training and development	0	16	37	4	0	57	2.21	0.559	81.8
1.2.3. Teamwork	3	18	30	3	0	54	2.39	0.685	92.3
1.2.4. Suggestion/Feedback/Appraisal System	1	7	42	6	0	56	2.05	0.553	81.8
1.2.5. Employee Turnover, Absenteeism, and Compensation	1	1	10	38	7	57	1.14	0.718	1.8
1.2.6. Ergonomic, clean and safe work environment, and results	46	10	1	0	0	57	3.79	0.453	98.2
Motivation Theory	0	6	34	14	3	57	1.75	0.714	10.7
Socio-technical Systems	0	2	10	41	4	57	1.18	0.601	5.5
2.1.1. Operational Vision and Strategy	0	9	41	7	0	57	2.04	0.533	10.7
2.2.1 Product Design and Development	3	7	36	11	0	57	2.04	0.731	27.3
2.2.2. Product Market Service	1	1	10	42	3	57	1.21	0.647	7.1
2.3.1. Suppliers	0	21	29	6	1	57	2.23	0.708	23.2
2.3.2 Customers	2	2	15	36	2	57	1.4	0.776	14.3
2.3.3. Distribution & Transport Alliances	0	4	35	17	0	56	1.77	0.572	7.3
2.4.1. Systematic identification and elimination of waste	51	3	1	0	0	55	3.91	0.348	98.1
2.4.2. Just-in-Time Operations	50	5	0	0	0	55	3.91	0.29	100
2.4.3. Cellular & Continuous Flow	52	4	0	0	0	56	3.93	0.26	100
2.4.4. Lean Tools for Continuous Improvement	50	6	1	0	0	57	3.86	0.398	100
Six Sigma/Problem Solving Techniques	0	6	38	9	3	56	1.84	0.682	14.5
Quantitative Decision-Making Techniques	1	3	36	13	2	55	1.78	0.686	15.1
Simulation Technique	1	2	8	39	7	57	1.14	0.743	7.3
Optimization Techniques	2	0	8	43	4	57	1.18	0.71	5.4

	4	3	2	1	0	Total	Mean	SD	Y%
Facilities Design and Layout	0	6	42	7	2	57	1.91	0.606	25
3.1.1 Administrative Vision & Strategy	1	7	45	3	1	57	2.07	0.563	83.9
3.1.2. Alignment & Systematic Business & Service Process Design	1	3	40	11	1	56	1.86	0.616	5.5
Supply Chain Logistics	2	2	42	9	1	56	1.91	0.64	7.3
Lean Accounting	1	3	14	34	4	56	1.34	0.769	9.1
Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	2	2	35	13	2	54	1.8	0.737	9.4
4.1.1 Quality Results	45	9	1	0	0	55	3.8	0.447	100
4.2.1 Cost & Productivity Results	46	9	0	0	1	56	3.77	0.632	98.2
4.3.1 Delivery and Customer Service Measurement	5	34	17	0	0	56	2.79	0.594	89.1
International Organization for Standardization (ISO) and Lean	1	3	38	11	3	56	1.79	0.706	7.3
Quality Management System (QMS)	2	5	39	7	2	55	1.96	0.719	14.8
5.1.1 Customer Satisfaction Results	0	11	33	11	1	56	1.96	0.687	12.7
5.2.1. Profitability Measurement	1	2	17	30	3	53	1.4	0.743	18.9
Lean Business Metrics	1	3	47	5	1	57	1.96	0.533	41.1
Total Supply Chain Cost	1	2	14	35	4	56	1.3	0.737	5.6

	SILVER								
	LEVEL OF IMPORTANCE								
Competency Areas	4	3	2	1	0	Total	Mean	SD	Y%
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	2	55	0	0	0	57	3.04	0.19	98.0
1.1.2. Respect for Humanity and Social Responsibility	3	10	35	9	0	57	2.12	0.73	25.9
1.1.3. Long and Short-term Planning	3	49	5	0	0	57	2.96	0.38	98.1
1.1.4. Principles of Lean leadership	56	0	0	0	0	56	4.00	0.00	100.0
1.1.5. Lean Corporate Culture	51	2	0	0	0	53	3.96	0.19	100.0
1.2.1. Principles of Empowerment	8	45	4	0	0	57	3.07	0.46	98.2
1.2.2. Employee training and development	7	48	2	0	0	57	3.09	0.39	100.0
1.2.3. Teamwork	50	2	2	0	0	54	3.89	0.42	100.0
1.2.4. Suggestion/Feedback/Appraisal System	5	44	7	0	0	56	2.96	0.47	96.4
1.2.5. Employee Turnover, Absenteeism, and Compensation	1	7	41	8	0	57	2.02	0.58	17.9

1.2.6. Ergonomic, clean and safe work environment, and results	54	3	0	0	0	57	3.95	0.23	100.0
Motivation Theory	4	37	14	1	1	57	2.74	0.70	85.7
Socio-technical Systems	1	29	26	1	0	57	2.53	0.57	71.4
2.1.1. Operational Vision and Strategy	5	45	7	0	0	57	2.96	0.46	100.0
2.2.1 Product Design and Development	7	45	5	0	0	57	3.04	0.46	96.4
2.2.2. Product Market Service	1	40	14	1	1	57	2.68	0.63	78.2
2.3.1. Suppliers	3	47	7	0	0	57	2.93	0.42	96.4
2.3.2 Customers	4	35	17	1	0	57	2.74	0.61	91.1
2.3.3. Distribution & Transport Alliances	0	46	10	0	0	56	2.82	0.39	90.9
2.4.1. Systematic identification and elimination of waste	52	3	0	0	0	55	3.95	0.23	100.0
2.4.2. Just-in-Time Operations	54	1	0	0	0	55	3.98	0.14	100.0
2.4.3. Cellular & Continuous Flow	55	1	0	0	0	56	3.98	0.13	100.0
2.4.4. Lean Tools for Continuous Improvement	55	2	0	0	0	57	3.96	0.19	100.0
Six Sigma/Problem Solving Techniques	2	41	11	1	1	56	2.75	0.64	83.6
Quantitative Decision-Making Techniques	3	40	11	0	1	55	2.80	0.62	79.6
Simulation Technique	2	25	24	5	1	57	2.39	0.77	54.5
Optimization Techniques	2	9	38	7	1	57	2.07	0.70	32.1
Facilities Design and Layout	10	40	6	0	1	57	3.02	0.67	94.6
3.1.1 Administrative Vision & Strategy	6	50	1	0	0	57	3.09	0.34	100.0
3.1.2. Alignment & Systematic Business & Service Process Design	5	40	11	0	0	56	2.89	0.53	94.5
Supply Chain Logistics	3	43	10	0	0	56	2.88	0.47	90.9
Lean Accounting	3	29	24	0	0	56	2.63	0.59	80.0
Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	2	18	33	1	0	54	2.39	0.60	83.0
4.1.1 Quality Results	50	4	1	0	0	55	3.89	0.37	98.1
4.2.1 Cost & Productivity Results	52	4	0	0	0	56	3.93	0.26	100.0
4.3.1 Delivery and Customer Service Measurement	45	10	1	0	0	56	3.79	0.46	98.2
International Organization for Standardization (ISO) and Lean	2	15	36	2	1	56	2.27	0.67	67.3
Quality Management System (QMS)	2	41	10	0	2	55	2.75	0.70	85.2
5.1.1 Customer Satisfaction Results	3	43	10	0	0	56	2.88	0.47	92.7
5.2.1. Profitability Measurement	4	33	16	0	0	53	2.77	0.58	88.7
Lean Business Metrics	6	48	2	0	1	57	3.02	0.55	98.2
Total Supply Chain Cost	3	39	13	0	1	56	2.77	0.63	81.8

Competency Areas	GOLD								
	LEVEL OF IMPORTANCE								
	4	**3**	**2**	**1**	**0**	**Total**	**Mean**	**SD**	**Y%**
1.1.1 Business vision, mission, values, strategies & goals, including resource allocation	57	0	0	0	0	57	4.00	0.00	100
1.1.2. Respect for Humanity and Social Responsibility	27	22	7	0	0	56	3.36	0.70	92.7
1.1.3. Long and Short-term Planning	54	3	0	0	0	57	3.95	0.23	100
1.1.4. Principles of Lean leadership	56	0	0	0	0	56	4.00	0.00	98.2
1.1.5. Lean Corporate Culture	52	0	0	0	0	52	4.00	0.00	100
1.2.1. Principles of Empowerment	53	4	0	0	0	57	3.93	0.26	100
1.2.2. Employee training and development	53	4	0	0	0	57	3.93	0.26	100
1.2.3. Teamwork	51	3	0	0	0	54	3.94	0.23	100
1.2.4. Suggestion/Feedback/Appraisal System	49	7	0	0	0	56	3.88	0.33	100
1.2.5. Employee Turnover, Absenteeism, and Compensation	29	22	4	2	0	57	3.37	0.77	91.1
1.2.6. Ergonomic, clean and safe work environment, and results	54	3	0	0	0	57	3.95	0.23	100
Motivation Theory	44	12	0	0	1	57	3.72	0.65	96.4
Socio-technical Systems	14	40	2	1	0	57	3.18	0.57	94.5
2.1.1. Operational Vision and Strategy	54	3	0	0	0	57	3.95	0.23	100
2.2.1 Product Design and Development	50	7	0	0	0	57	3.88	0.33	100
2.2.2. Product Market Service	44	13	0	0	0	57	3.77	0.42	94.6
2.3.1. Suppliers	52	5	0	0	0	57	3.91	0.29	100
2.3.2 Customers	50	7	0	0	0	57	3.88	0.33	100
2.3.3. Distribution & Transport Alliances	42	14	0	0	0	56	3.75	0.44	98.2
2.4.1. Systematic identification and elimination of waste	53	2	0	0	0	55	3.96	0.19	96.3
2.4.2. Just-in-Time Operations	51	3	1	0	0	55	3.91	0.35	96.3
2.4.3. Cellular & Continuous Flow	51	4	0	1	0	56	3.88	0.47	98.2
2.4.4. Lean Tools for Continuous Improvement	52	5	0	0	0	57	3.91	0.29	96.4
Six Sigma/Problem Solving Techniques	35	16	3	1	1	56	3.48	0.83	90.9
Quantitative Decision-Making Techniques	40	12	2	0	1	55	3.64	0.73	92.6
Simulation Technique	9	36	8	3	1	57	2.86	0.81	74.5
Optimization Techniques	7	34	12	3	1	57	2.75	0.81	78.2

Facilities Design and Layout	43	11	1	1	1	57	3.65	0.77	92.9
3.1.1 Administrative Vision & Strategy	55	2	0	0	0	57	3.96	0.19	100
3.1.2. Alignment & Systematic Business & Service Process Design	48	8	0	0	0	56	3.86	0.35	100
Supply Chain Logistics	43	13	0	0	0	56	3.77	0.43	100
Lean Accounting	42	13	1	0	0	56	3.73	0.49	100
Materials Requirement Planning (MRP)/Enterprise Resource Planning (ERP)	29	22	2	1	0	54	3.46	0.67	92.5
4.1.1 Quality Results	51	2	2	0	0	55	3.89	0.42	94.4
4.2.1 Cost & Productivity Results	52	3	1	0	0	56	3.91	0.35	100
4.3.1 Delivery and Customer Service Measurement	51	3	2	0	0	56	3.88	0.43	98.2
International Organization for Standardization (ISO) and Lean	28	23	4	0	1	56	3.38	0.78	90.9
Quality Management System (QMS)	40	10	3	0	2	55	3.56	0.90	90.7
5.1.1 Customer Satisfaction Results	48	7	1	0	0	56	3.84	0.42	98.2
5.2.1. Profitability Measurement	45	9	0	0	0	54	3.83	0.38	100
Lean Business Metrics	52	4	0	0	1	57	3.86	0.58	96.5
Total Supply Chain Cost	45	10	0	0	1	56	3.75	0.64	98.2