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Professional Learning and Lean Manufacturing

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Global competition and a down-sized labor force require manufacturers to use lean manufacturing practices. Current professional development models, however, are suboptimal in guiding efforts of first line supervisors to help workers improve their skills in solving manufacturing problems. This study employed an interpretive qualitative research methodology to explore what supervisors and workers experienced as the key factors that helped workers learn how to use lean manufacturing practices. Eight individuals who worked in an aerospace manufacturing plant located in the northeast United States participated in the study. Six of the participants were first line supervisors and two were first-line workers. Data collection methods included a demographic questionnaire and a semi-structured audiotaped interview. Data were analyzed using open coding and constant comparative methods. The researcher found that, in this plant setting, the key factors that influenced how workers learned lean manufacturing practices were: (a) sharing perspectives, (b) engaging in rich learning experiences, (c) ongoing support for learning, and (d) engaging in team-based learning. The results of this study may provide useful guidance to first line supervisors as they design a program that helps workers develop lean manufacturing skills. Ultimately this program could assist first line supervisors in their efforts to guide workers as they solve new manufacturing problems within the constraints of a downsized economy and a globally competitive industry.

Professional Learning and Lean Manufacturing

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The journey I took to pursue the PhD was at best, rather peculiar. Nearing the end of my academic portion of this program, I experienced unexpected life events that significantly challenged my ability to pursue this degree in the timeframe I hoped. During this time I left a long-standing career, learned how to become an independent learning consultant, became a founder of a tech startup business that uses adult learning principles, and remained as a devoted husband and father to four young, active school children. I must admit that I came very close to leaving the PhD program because of a busy and hectic lifestyle, but there was a little burning fire inside that kept me going. I have grown spiritually in many ways in the last several years and the completion of this doctoral study could not have happened without the unconditional support of my wife, Wendianne, our children, and my major advisor, Dr. Barry Sheckley. I am forever grateful for this – thank you.

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CHAPTER I

Background

In today's world economy enhancing the learning of a professional workforce is recognized as one of the key strategies for businesses to successfully compete and maintain a presence in global markets (Sala-I-Martin, Blanke, Drzeniek, Geigler, & Mia, 2011). This strategy is evident in the United States where businesses invest $126 billion per year on professional learning (Patel, 2010) – a practice that may contribute to the number one ranking in the world that US businesses have for innovation capacity (Sala-I-Martin et al., 2011).

In the case of advanced manufacturing organizations, workers are trained to be innovative with lean manufacturing processes (Womack, Jones, & Roos, 1990) so that the company can remain competitive in the global marketplace (e.g., The Boeing Company, Mecham, 2004). The lean manufacturing approach synergistically uses various processes including just-in-time (JIT) practices (Monden, 1981), total quality management (TQM) programs (Deming, 1986; Ishikawa, 1985), total preventive maintenance (TPM) schedules (Tsuchiya, 1992), work teams, cellular manufacturing, and supplier management. These procedures help manufacturers create high quality products, at low cost, with little or no waste (Shah & Ward, 2003).

As global competition increased during the last decade, however, manufacturers faced the double challenge of increasing their innovative use of *lean manufacturing practices* (LMP) while simultaneously cutting employee ranks. U.S. manufacturing employment declined 33.2% from 2000 to 2010 (Statistics, 2011). During the December 2007 – June 2009 recession alone, manufacturing employment declined 15% in the U.S.

(Barker, 2011). This drastic decline in the number of employees and the related increase in global competition challenged leaders to devise ways to help workers use LMP in more effective and innovative ways.

Statement of the Problem

To address the dual challenge of using LMP within the constraints of a downsized labor force and the demands of a competitive landscape, manufacturing leaders are continually seeking new ways to improve workers' abilities to implement practices that solve manufacturing problems. Because traditional workshop-based training is often not effective, leaders are looking for other approaches to help workers improve their skills (Badurdeen, Marksberry, Hall, & Gregory, 2010).

Holton and Baldwin (2003) emphasized that enhancing professional learning may not just be a matter of re-engineering traditional workshop-based training approaches because such training programs often do not provide workers with the guidance and coaching required to implement LMP (Badurdeen et al., 2010). This situation persists because supervisors receive little guidance on *how* to help employees transfer their learning into enhanced LMP (Holton & Baldwin, 2003). Perhaps for this reason supervisors in manufacturing settings often wrongly focus on directly improving production rather than on helping workers improve their skills in using LMP as a means to improve production (Badurdeen et al., 2010). For these reasons, as a way to counter the suboptimal outcomes of traditional workshop-based training programs, manufacturing leaders could benefit from improving their own skills in guiding workers to use LMP when faced with lean manufacturing problems. In turn, increased use of effective LMP could contribute to the success of a manufacturing organization.

In their research in successfully managed lean manufacturing organizations Robinson and Schroeder (2009) found a strong link between first line supervisors (FLSs) who facilitated professional learning effectively, workers' abilities to use LMP, and implementation of LMP. James-Sommer (2008) reported that FLSs are the "lynchpin to business results and to an organization's success but only if they are provided with the right knowledge, skill sets, and tools to do the job" (p. 3). As these researchers suggested, FLSs would be in the best position to help first-line workers innovatively implement LMP – while facing increasing competition and decreasing employment levels – if they had the knowledge and skills to enhance workers' professional learning. A problem exists when FLSs attempt to enhance the learning of first-line workers: They find limited guidance in the literature on how to enhance workers' professional learning.

As a first step in addressing the problem that FLSs face – finding a better way to help workers improve their skills to implement LMP – this study explored the key factors that influenced how workers learned LMP in a specific manufacturing setting.

Conceptual Framework, Literature Themes, and Propositions

This study is founded on key tenets from the Trio Model of Adult Learning (Sheckley, Kehrhahn, Bell, & Grenier, 2007). The Trio Model (see Figure 1) outlines three major components of an optimal professional learning process: individual attributes (including *mental models*, *self-regulation*, and *motivation*), key experiences (including activities that build *analogical reasoning*, *mental model complexity*, and *tacit knowledge*), and environmental affordances (including *challenges* and *supports*).

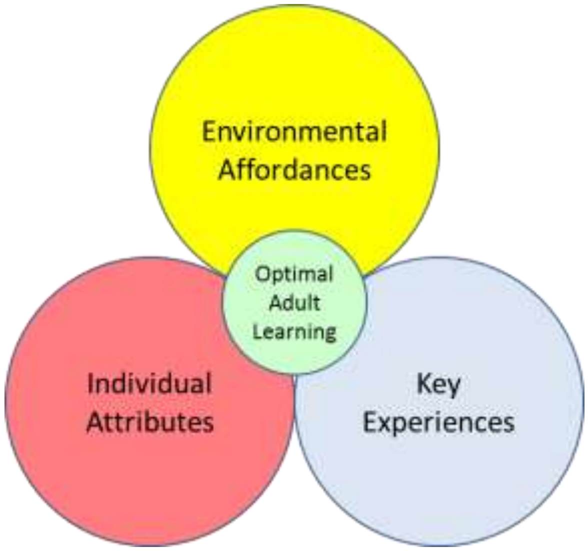

Figure 1. Trio Model of Adult Learning.

According to the model, optimal learning occurs when all components of the model are employed in a balanced and integrated manner. In the context of this study, optimal learning for manufacturing workers would be based on the use of all three components of the Trio Model; if any one of these components is missing, then professional learning is not optimal (Sheckley et al., 2007). This model forms the basis for three literature themes that are discussed in this chapter. Each theme also suggests a proposition for enhanced professional learning in a lean manufacturing setting.

Literature Theme 1: Learning is Enhanced When Individuals Surface and Refine the Mental Models that Guide Their Problem Solving

The concept of mental models, which is one key tenet of the individual attributes component of the Trio Model, refers to an individual's view of how the world works. Markman and Gentner (2001) define a mental model as "a representation of some domain or situation that supports understanding, reasoning, and prediction" (p. 228). Mental models "influence how we understand the world and how we take action" (Senge, 1990, p. 8). In the process of learning, mental models help provide an initial framework on

which new information can be attached (Zsambok & Klein, 1997). By understanding the nature of their existing mental models, people can refine and augment these models to create new mental models that can help improve business outcomes (Gentner, Holyoak, & Kokinov, 2001).

The research outlined in Table 1 indicates that (a) learning is enhanced when individuals surface and refine their mental models and that (b) learners can surface and refine their existing mental models by creating concept maps (Austin, 1993; Bascones & Novak, 1985; Nicoll, Francisco, & Nakhleh, 2001), identifying missing relationships between concepts on a partially constructed concept map (Zittle, 2001), and using predefined mental model structures in the creation of concept maps (Stoyanov & Kommers, 2006). This research will be discussed more fully in the paragraphs that follow. After a review of the three literature themes outlined in this chapter, gaps in this research will be delineated.

Table 1

Effect of Surfacing and Refining Adult Learners' Mental Models

Authors	Methods	Questions	Results and effect sizes
Austin (1993)	Subjects: ▪ 22 undergraduate students enrolled in physics course Design: Quantitative ▪ Mean *z*-scores	Do concept maps help participants' ability to solve multi-step problems?	Participants who created their own concept maps achieved a greater gain in z-scores (for *multi-step problem* test) than those who did not create concept maps ▪ ES_r = .48

(continued)

Authors	Methods	Questions	Results and effect sizes
Bascones and Novak (1985)	Subjects: ▪ 76 ninth-grade physics students Design: Quantitative ▪ ANOVA	What is the effect of concept mapping instruction on physics problem solving ability?	Among students with high intellectual abilities, those who created their own concept maps solved more physics problems than those who received traditional instruction ▪ $ES_r = .64$
Nicoll, Francisco, and Nakhleh (2001)	Subjects: ▪ 20 Purdue University chemistry students Design: Mixed Qualitative ▪ Open-ended, semi-structured interviews converted to concept maps Quantitative ▪ Means, *t*-test	To what extent do students link related concepts in a chemistry course by creating concept maps?	Participants who created their own concept maps versus those who did not create concept maps ▪ Greater # of *total nodes* (concepts) $ES_r = .38$ ▪ Greater # of *useful links* (relationships) $ES_r = .47$
Zittle (2001)	Subjects: ▪ 139 participants from ten institutions for higher learning; located in 5 countries Design: Quantitative ▪ One-way ANOVA	What is the effect of a select and fill-in (SAFI) concept map activity on analogical transfer to solve a problem?	Participants who identified missing relationships between concepts using the SAFI method required fewer hints to solve a problem when compared to: ▪ *Study text* method $ES_r = .52$ ▪ *Study map* method $ES_r = .91$

(continued)

Authors	Methods	Questions	Results and effect sizes
Stoyanov and Kommer (2006)	Subjects: ▪ 32 fourth-year undergraduate students Design: Quantitative ▪ Two-way ANOVA	What is the effect of the type of concept mapping on concept mapping production?	Participants who created their own concept maps with a given set of mental model structures demonstrated a deeper perception of the problem space than participants who used just the traditional concept map graphical conventions ▪ *Number* of new ideas ES_r = .67 ▪ *Variety* of new ideas ES_r = .51

Austin (1993) investigated the use of concept maps as a method to help learners surface their mental models and develop multi-step problem solving skills. The sample was drawn from undergraduate students (*n* = 22) who enrolled in an introductory college physics course. The experimental group (three females, seven males) received traditional physics instruction and used concept maps to surface their mental models of physics concepts and the relationships between physics concepts throughout the semester. The control group (three females, nine males) received traditional physics instructions, but did not use concept maps. One of the outcomes measured was the gain in *z*-scores from a physics pretest to posttest, each containing six multi-step problems. The author found that the relationship between concept mapping and the variable *z-score* gains was large (ES_r = .48). Austin suggests that the experimental group had "a better understanding of the links between the concepts" (p. 101). Austin concluded that multi-step problem solving performance in physics seems to link to the quality of the student's concept map which, in turn, "reflects the student's cognitive organization [i.e., mental model] of the subject

matter being studied" (p. 119). As applied to professional learning for manufacturing workers, these findings suggest that workers who surfaced their understanding of the relationships between work goals and processes could help expand their mental models in ways that might improve their ability to solve manufacturing problems.

Austin's (1993) findings are consistent with the earlier work done by Bascones and Novak (1985), who explored how a concept mapping instruction system (i.e., surfacing mental models of key concepts) affects problem solving skills. Their research was carried out in a high school physics course in Venezuela. Ninth-grade students (n = 76) were randomly selected for the sample. Two groups of 38 subjects were created with similar intelligence levels. The experimental group created their own concept maps in class whereas the control group received traditional instruction and did not create concept maps. Each group was further broken down into three sub-groups of intellectual abilities by using their Raven (1938) test scores. The dependent variable measured was the participant's score on a posttest that consisted of eight novel physics problems. The authors found that among students with the highest intellectual abilities, those who received concept-mapping instruction were more likely to solve multiple physics problems (ES_r = .64). The results, according to the authors, are related to students' ability to "identify [i.e., bring to the surface] specifically relevant concepts and recognize non-arbitrary relationships between these concepts" (p. 253). The authors concluded from their findings that the "broader the relevant cognitive structure [i.e., mental model] the student has in physics, the better his/her success with problem-solving will be" (p. 260). As related to professional learning for manufacturers, this research suggests that even the high performing workers could benefit from surfacing the mental models they use to

guide their practice. In turn, this surfacing of mental models could lead to improved lean manufacturing problem solving abilities.

In related research Nicoll et al. (2001) also found that the process of surfacing mental models enhances learners' problem solving abilities. Nicoll and associates evaluated to what extent students linked related concepts in a freshman-level general chemistry course. The sample included traditional undergraduate science and engineering students (n = 20). The treatment group (eight females, two males) used concept maps to surface their own concepts and relationships in their homework and quizzes. The treatment for the control group (five females, five males), who did not create concept maps in the course, was limited to traditional lectures in the classroom. A qualitative inquiry was used to examine the outcomes at the end of the course semester. Using semi-structured, open-ended interviews the researchers asked students in both groups to give their solutions for the given chemistry problems. The interview data were transcribed and used to construct a concept map for each student. For each map, the total number of concepts and total number of useful concept relationships were measured as dependent variables. Nicoll et al. determined that having students generate concept maps during the course had a large positive relationship to their ability to create more chemistry concepts (ES_r = .38) and more useful relationships (ES_r = .47) between those concepts. According to the researchers, when the students were creating their concept maps, they were "correctly integrating these concepts from different domains into their knowledge structures [i.e., mental models]" (p. 1115). Nicoll et al. concluded that "these students have more complex maps and are therefore able to solve more complex problems than control students" (p. 1116). As applied to professional learning for manufacturing

workers, this study suggests that workers, who bring to the surface more concepts of work goals and processes, could build more relationships between those concepts. In turn, they could develop more complex mental models that would effectively guide their work in solving lean manufacturing problems.

The act of surfacing mental models is also substantiated by the research of Zittle (2001). The goal of Zittle's research was to examine the effects of a web-based select-and-fill-in (SAFI) concept map method on analogical transfer and the ability to solve a target problem. The WebCT® application on the Internet provided the setting for the study. Using email solicitation, the author recruited participants (N = 139) from ten institutions of higher learning, located in five different countries on four continents (59% female, 41% male, 25-34 years of age). The participants were randomly assigned to one of three experimental groups: Study Text (ST), Study Map (SM), or SAFI. When two original and analogous problem sets were given at the outset of the program, the ST group studied the text description, the SM group studied a previously completed concept map, and the SAFI group surfaced missing concepts in partially constructed maps. At the conclusion of the program, all participants were asked to solve two target problem sets. The unit of measure for the outcome was the number of problem hints each participant needed to correctly solve the target problem. The author's research revealed that when the SAFI method was used, participants were more likely to solve the target problems with fewer problem hints when compared to the ST method (ES_r = .52) and the SM method (ES_r = .91). According to the researchers the transfer success could be from the "participant's ability [i.e., via an enhanced mental model] to recognize the underlying isomorphic structure of the analogy problems" (p. 116). Zittle came to the conclusion that

the “action of mapping [i.e., surfacing mental models] was an important ingredient for the increased frequency of transfer in the SAFI group” (p. 118). The author’s work supports the premise that if workers in a manufacturing setting are asked to surface the mental models they use to guide their practice, then workers could enhance their lean manufacturing problem solving skills.

This premise is supported by the research of Stoyanov and Kommers (2006), who investigated the role that concept mapping instruction had in ill-structured problem solving situations. The study took place within an undergraduate university setting. The sample included fourth-year undergraduate students ($n = 32$), who were randomly assigned to the experimental and the control group. The control group was taught to use the *classical* concept mapping (CCM) method using graphical conventions (e.g., flowchart symbols). The experimental group was taught to apply the *new* concept mapping (NCM) method, which included predefined mental model structures for solving problems as well as concept mapping graphical conventions. Both groups were asked to solve a case in which a fourth-year university student was confronted with a problem to make a decision about his future. Similar to the work of Nicoll et al. (2001), the authors in this study found that the NCM method had a positive relationship to measures of *broad perception* in terms of the number of *new* ideas ($ES_r = .67$) and on the *variety* of new ideas ($ES_r = .51$) for solving the problem. The authors concluded that the NCM method “enables a broaden [*sic*] perception [i.e., refining existing mental models] with more and diverse information items and more complex labels on the links” (p. 311). Additionally, the authors stated that the NCM method “proved a better approach in ill-structured problem situations than the classical concept mapping instruction” (p. 313). Specifically,

as applied to professional learning for manufacturing workers, Stoyanov and Kommers' work highlights the opportunity for workers to refine their existing mental models, via NCM, on work goals and processes. If FLSs can help workers use predefined mental model structures (e.g., approach to on-time delivery) to surface key features – the strengths and limitations – of the ideas and perspectives (i.e., mental models) they actually use to guide their practice, then workers could be better prepared to solve ill-structured lean manufacturing problems.

In summary, Literature Theme 1 evident in the research outlined in Table 1, states that *learning is enhanced when individuals surface and refine the mental models that guide their problem solving*. This theme suggests that learners can surface their mental models through activities that help them to reflect upon the key features of the ideas and perspectives they actually use to guide their practice. Further, the research suggests that learners could refine their mental models by identifying missing relationships between concepts or ideas presented to them in a predefined framework (e.g., one-piece flow) and the ideas they actually use in practice. As applied to a manufacturing setting, this research suggests that FLSs could help workers learn how to use LMP by engaging them in activities that surface and refine their mental models of solving new lean manufacturing problems. This research also suggests Proposition 1 that could be used in LMP settings: *Professional learning in a lean manufacturing setting could be enhanced if workers surfaced and refined the mental models they use to guide their work.*

Literature Theme 2: Learning is Enhanced When Individuals Engage in Key Experiences that Increase the Complexity of the Mental Models They Use to Guide Their Thinking

Although Literature Theme 1 focused on the surfacing and refining of individuals' mental models, Literature Theme 2 suggests that key experiences add complexity to learners' mental models (see Table 2). The studies included in this review indicate that increased mental model complexity is linked to the experience of *doing* (Van Boven & Thompson, 2003), to multifaceted experiences (Barnett & Koslowski, 2002; Wiedenbeck, Fix, & Scholtz, 1993; Wineburg, 1991), and to the use of predefined mental model structures (Ferrario, 2003). This theme will be discussed more fully in the paragraphs that follow. After a review of this theme, gaps in this research will be delineated later in this chapter.

Table 2

Effect of Key Experiences that Increase Adult Learners' Mental Model Complexity

Authors	Methods	Questions	Results and effect sizes
Van Boven and Thompson (2003)	Subjects: ▪ 201 undergraduate students enrolled in psychology courses Design: Quantitative ▪ ANOVA	Compared to didactic training, does experiential training (e.g., doing negotiation tasks) produce better results in trade-off insights?	Participants who had prior negotiation task experience (by doing) were more likely to solve novel negotiation tasks than participants who did not have prior negotiation task experience (didactic training) ▪ Higher *preference insight* scores $ES_r = .51$

(continued)

Authors	Methods	Questions	Results and effect sizes
Barnett and Koslowski (2002)	Subjects: ▪ 12 business consultants ▪ 12 restaurant managers ▪ 12 non-business undergraduates Design: Mixed Qualitative ▪ Semi-structured interviews Quantitative ▪ ANOVAs	What is the difference between problem solving performance of two kinds of experts (business consultants and restaurant managers) and novices on novel problems?	Despite a lack of restaurant experience, business consultants outperformed restaurant managers and novices in solving a novel restaurant business problem ▪ Greater *causal reasoning* ES_r = .41 ▪ More *causally-supported solutions* ES_r = .33
Wiedenbeck, Fix, and Scholtz (1993)	Subjects: ▪ 20 novice computer programmers (undergraduate students) ▪ 20 expert computer programmers (professionals) Design: Quantitative ▪ ANOVAs	How do novice programmers and expert programmers differ in their mental models when solving a computer program problem?	Expert programmers' mental models guided them to use more effective strategies to solve a computer program problem than novice programmers ▪ Greater *presence of hierarchy in mental representation* ES_r = .44 ▪ Greater *linking of variable names to the context* in which they appeared ES_r = .51

(continued)

Authors	Methods	Questions	Results and effect sizes
Wineburg (1991)	Subjects: ▪ 8 historians from universities in San Francisco Bay area ▪ 8 high school history students from same area Design: Mixed Qualitative ▪ Think-aloud interviews Quantitative ▪ Means, *t*-tests, *F*-tests	How do historians (experienced) and history students (inexperienced) differ in their reasoning when solving a historical painting problem?	Historians' mental models of picture evaluation protocols resulted in more evaluative statements than history students ▪ *Quality of Statements* $ES_r = .74$
Ferrario (2003)	Subjects: ▪ 219 emergency nurses (173 nurses with 5 or more years of experience; 46 nurses with < 5 years of experience) Design: Quantitative ▪ One-way ANOVA	Are heuristics used more frequently by experienced emergency nurses than by less-experienced emergency nurses when solving (i.e., diagnosing) patient problems?	Experienced emergency nurses used the *Judging by Perceived Causal Systems* mental model structure more than less-experienced nurses to solve patient problems ▪ $ES_r = .27$

Van Boven and Thompson's (2003) work highlights the importance of mental model complexity during a negotiation. The goal of their study was to examine the "association between negotiation outcomes and mental models" (p. 387). From a population of undergraduate students ($N = 201$) enrolled in psychology courses with

approximately equal number of males and females, participants were randomly assigned as pairs to standard negotiation (*n* = 110), experiential training (*n* = 46), and didactic training conditions (*n* = 23). Experienced negotiators (*n* = 22) were selected from an advanced undergraduate negotiation course. Following these conditions, participants were asked to solve a novel commodity negotiation problem. One of the dependent variables measured was the *preference insight* score, a measure that represented a component of mental model complexity. According to this study, experiential training (i.e., *doing* negotiations before being confronted with a novel problem) had a positive relationship with the participants' ability to solve the problem correctly (i.e., preference insight score) (ES_r = .51). From this finding, the authors suggest that the participants' "mental models reflected greater insight into the underlying structure of the task, and into the integrative processes of trading" (p. 397) and the solvers had "mental models that reflected greater understanding of the negotiation's payoff structure" (p. 400). As applied to a manufacturing setting, this research suggests that FLSs could help workers add complexity to the mental models workers employ to guide their use of LMP by engaging them in key experiences that involve them in actually *doing* lean manufacturing tasks.

The act of *doing* in a variety of structurally related experiences plays another important role in increasing mental model complexity, as indicated in the work of Barnett and Koslowski (2002). The authors examined two kinds of business experts, business consultants and restaurant managers with the goal of finding out which group developed more effective solutions for a novel restaurant business problem. Near a small town in upstate New York, a sample of business consultants (*n* = 12), restaurant managers (*n* = 12), and undergraduate students (*n* = 12) participated in this qualitative study. Given a

hypothetical restaurant business problem, the participants were asked to think aloud as they arrived at their solutions. The transcribed, audiotaped responses were then coded to count the number of *causal reasoning* components and *causally supported solutions*, two of the dependent variables measured. Their study revealed that in comparison to restaurant managers, “business consultants” demonstrated a greater ability to use *causal reasoning* (ES_r = .41) and to offer *causally supported solutions* (ES_r = .33). These findings were captivating because, according to the authors, they suggest that there is a fundamental difference in mental model complexity between the two groups who faced the same problem. In this case, the authors contend that the difference exists because the business consultants’ “enhanced theoretical understanding [i.e., developed mental models] is derived from the wide variety of business problem-solving [i.e., structurally related] experience to which the consultants, but not the restaurant managers, have been exposed” (p. 260). In the authors’ conclusion, they stated that the “explanatory variable with the most convincing existing empirical support is the degree of substantive variability in the consultants’ experience, which is lacking in the restaurant managers’ experience” (p. 262). Barnett and Koslowski’s research has implications for helping workers learn how to use LPM. It suggests that engaging workers in multi-faceted experiences could add to the complexity of the mental models they use when implementing LMP. It also suggests that key lean manufacturing experiences (e.g., working in multiple product lines) could increase the complexity of workers’ mental models in ways that help them solve lean manufacturing problems in novel situations (e.g., launching a new product line in the factory).

These findings on wide-ranging and multi-faceted key experiences are corroborated by the work of Wiedenbeck et al. (1993). Their work examined the performance of expert and novice computer programmers with the purpose of understanding the complexity of mental models that guided their problem solving methods. The sample included undergraduate, novice programmers (n = 20) from the University of Nebraska and the University of South Dakota, who completed a semester of Pascal programming. The sample also included professional, expert programmers (n = 20) from Nebraska and Oregon who had a variety of key experiences in teaching, writing, and maintaining large programs in multiple languages. Using an experimental design, the participants were asked to solve a 135-line Pascal programming problem by answering a series of questions. Wiedenbeck et al.'s results revealed that in comparison to novice programmers, expert programmers more often used *hierarchical, layered structures* (ES_r = .44) and more often linked *variable names* to the context in which they appeared (ES_r = .51), with both dependent variables contributing to an overall problem solution. The authors indicated that the experts seemed "to seek the relations of objects, which leads to a connected view of the program [i.e., mental model complexity]" (p. 807). The researchers concluded that mental model complexity is "likely to be developed as students carry out programming tasks, such as debugging and modification of numerous programs (i.e., multi-faceted experiences), and learn from a distillation of these experiences" (p. 809). Similar to Barnett and Koslowski's (2002) research, this study again suggests that workers could expand the complexity of the mental models they employ to guide their use of LMP by engaging in a variety of intricate lean manufacturing experiences.

Barnett and Koslowski's (2002) and Wiedenbeck et al.'s (1993) work is supported by the earlier research completed by Wineburg (1991), who studied the experiences and mental model complexities of university historians (*n* = 8) and high school history students (*n* = 8), who were asked to reconstruct historical events. The historians' experience included doctoral research in history and teaching college-level history courses, whereas the students' experience was limited to a traditional, high school history class. In this qualitative inquiry, participants solved an ill-structured problem in which they reviewed written and pictorial documents to reconstruct the Battle of Lexington. The participants were asked to think-aloud as they developed their solutions. From a quantitative analysis of audiotaped and transcribed interview data, the author found that in contrast to students, the expert historians were more likely to produce better quality statements (ES_r = .74). In the absence of giving a determinate conclusion, the author still believed the effect was partly because the historians' "background knowledge [i.e., from key experiences and increased mental model complexity] contributed to the differences" and because the historians "corroborated and discorroborated key features . . . to represent what could and what could not be known" from the pictures and documents (p. 83). In the world of manufacturing, this study further supports the idea that: (a) learning programs that include multi-faceted experiences could add complexity to workers' mental models and (b) workers who gain multi-faceted, lean manufacturing experiences in other ways (such as research and teaching), could increase the complexity of their mental models related to using LMP.

From multi-faceted experiences, the development of mental model complexity plays an important role in solving problems, as was found in the recent work of Ferrario

(2003). The goal of her study was to compare the mental models of diagnostic reasoning between expert and novice emergency nurses. A quantitative, diagnostic reasoning survey instrument was mailed out to a sample of emergency nurses (n = 219, 86% female, 14% male, M = 42.4 years of age, 79% ≥5 years' experience). The survey contained four medical problem situations, each requiring the use of a different mental model, for the participants to solve by selecting the best *diagnostic reasoning* option from a multiple-choice list. One of the findings was that in comparison to inexperienced nurses, experienced emergency nurses were more likely to use the *Judging by Perceived Causal Systems* diagnostic reasoning option to solve patient problems (ES_r = .27). According to the author, this may be because experienced nurses used "cases from prior . . . [key] experiences to aid their reasoning more often than less-experienced nurses did" (p. 48). She concluded that "heuristics are mental representations [i.e., developed from increased mental model complexity] that shortcut the reasoning process and allow nurses to reach quick decisions [i.e., on a solution to the problem]" (p. 50). This study suggests that professional learning programs in a manufacturing setting, that include key experiences, could build the workers' mental model complexity and that key experiences (e.g., diagnosing causes of assembly line delays for different products) could increase the complexity of mental models that guide their work.

In summary, Literature Theme 2 is derived from the research outlined in Table 2: *Learning is enhanced when individuals engage in key experiences that increase the complexity of the mental models they use to guide their thinking*. This theme suggests that learning programs that involve multi-faceted, key experiences could build learners' mental model complexity. Further, this theme suggests that key experiences could

increase the complexity of the learners' mental models that guide their work in using LMP. As applied to a manufacturing setting, FLSs could establish an enhanced learning program by engaging workers in planned, multi-faceted experiences that are crucial to solving lean manufacturing problems. This research suggests that workers would benefit from engaging in key manufacturing experiences because such engagement would help them expand the complexity of the mental models that they use to guide their work in solving lean manufacturing problems. This research also suggests Proposition 2 that could be used in LMP settings: *Professional learning in a lean manufacturing setting could be enhanced if workers engaged in key experiences that increased the complexity of the mental models they used to guide their work.*

Literature Theme 3: Learning is Enhanced When Individuals Engage in Team-Based Knowledge Construction Processes

Literature Theme 3 examines how learning is enhanced when learners engage in team-based knowledge construction processes. The research outlined in Table 3 suggests that learning is enhanced when individuals engage in team-based knowledge construction processes. In this body of research there is evidence that a team-based knowledge construction process occurs in teams who: (a) possess similar and accurate mental models (Marks, Zaccaro, & Mathieu, 2000), (b) collaborate around a problem of practice (Jeong & Chi, 2000), (c) use a structured concept mapping process (Fischer, Bruhn, Gräsel, & Mandl, 2002; Okebukola, 1992), or (d) create visual mental models (Massey & Wallace, 1996). As part of this knowledge construction process, teams collaborate to develop shared mental models. According to the research, teams that work together to develop shared mental models are more likely to outperform other teams. This theme will be

discussed more fully in the paragraphs that follow. After this discussion, gaps in the research for all three literature themes will be delineated.

Table 3

Effect of Team-Based Knowledge Construction Process on Adult Learners

Authors	Methods	Questions	Results and effect sizes
Marks, Zaccaro, and Mathieu (2000)	Subjects: ▪ 237 undergraduates from a large mid-Atlantic university ▪ Participants subdivided into 79 three-person tank platoon teams Design: Quantitative ▪ ANOVAs	Is mental model similarity positively associated with team performance? Is mental model accuracy positively associated with team performance?	Mental model *similarity* had positive effect on team performance. ▪ ES_r = .23 Mental model *accuracy* had positive effect on team performance. ▪ ES_r = .48
Jeong and Chi (2000)	Subjects: ▪ 20 dyad teams of undergraduate students at University of Pittsburgh Design: Mixed Qualitative ▪ Audiotape ▪ Video tape Quantitative ▪ ANCOVAs ▪ *t*-test	Does learning in a team-based partnership lead to construction of shared knowledge among participants?	Team-based knowledge construction process has an effect on development of shared mental models ▪ ES_r = .81 Team-based knowledge construction process enables team to correctly solve blood path circulation problem ▪ 0% correct at *pre-test* (before team-based knowledge construction process) ▪ 50% correct at *post-test* (after team-based knowledge construction process)

(continued)

Authors	Methods	Questions	Results and effect sizes
Fischer, Bruhn, Grasel, and Mandl (2002)	Subjects: ▪ 32 Educational Psychology students in their 3rd to 5th semester at the University of Munich ▪ Participants subdivided into 16 dyad teams Design: Quantitative ▪ *t*-tests ▪ means	To what extent can the team-based knowledge construction process outcome be improved with content-specific visualization?	Students who used content-specific maps outperformed students who use non-content specific maps ▪ *Solution quality* ES_r = .65
Okebukola (1992)	Subjects: ▪ 60 pre-degree biology students at Lagos State University (Nigeria) ▪ Participants subdivided into three 20-person teams Design: Quantitative ▪ ANOVAs	Does a concept mapping, ability facilitate team problem solving behavior in science?	The concept mapping 'cooperative group' had the highest mean total problem solving score for three biology problems compared to individuals who did *not use* concept maps ▪ ES_r = .52

(continued)

Authors	Methods	Questions	Results and effect sizes
Massey and Wallace (1996)	Subjects: ▪ 45 students from university organization behavior class, from which 12 teams of 3 or 4 students were formed Design: Mixed Qualitative ▪ Video tapes ▪ Questionnaire Quantitative ▪ Descriptive	How do mental representational aids facilitate the exchange of individual perspectives and the development of shared mental models?	The teams who used the most effective team-based knowledge construction process had greater gains in problem solving scores [a] ▪ *Most effective group* Average score = 11.75 ▪ *Least effective group* Average score = 4.93 ▪ *Ineffective group* Average score = (-21.1)

[a] Insufficient data to calculate effect size.

Marks, Zaccaro, and Mathieu (2000) explored how shared mental models contribute to team performance in problem solving. In an experimental study, triad teams (n = 79) made up of undergraduate students at a large mid-Atlantic university were asked to solve a novel battlefield problem in a computer-based simulation. The authors found that amongst team members, there was a relationship between mental model similarity and team performance (ES_r = .23) and a relationship between mental model accuracy and team performance (ES_r = .48). This finding suggests that teams with similar and accurate mental models initially help team members adapt their mental models to a shared knowledge structure (e.g., strategies, mode of operation) that enables them to solve novel problems. The authors claim this is because "a characteristic of adaptive mental models appears to be flexibility, such that teams that are able to shift knowledge structures accurately and in similar ways are likely to be successful in novel contexts" (p. 982). This adaptive characteristic adds support to the theme that shared mental models contribute to

team problem solving skills thus emphasizing the importance of a team-based knowledge construction process. In their conclusion, the authors believed that "understanding the cognitive influences and behavioral actions that affect team performance is critical [when confronted with novel problems]" (p. 984). In the context of a professional learning program in a manufacturing setting, this study suggests that workplace teams who possess similar and accurate mental models (e.g., how to reach and sustain on-time delivery of parts) could be more likely to outperform other teams who attempt to solve lean manufacturing problems in novel situations.

Although shared mental models could contribute to team performance, it is important to review the knowledge construction process involved in building shared mental models. For example, in Jeong and Chi's (2000) research the authors' primary purpose was to see if a knowledge construction process contributed to the development of shared mental models. At the University of Pittsburgh, undergraduate dyad teams (n = 20) who had not taken college-level biology courses participated in this qualitative study. Individuals were pre-tested by being asked to solve a human blood circulatory system problem in which they had to draw (on paper) the correct blood path. Then dyad teams were formed and each pair was asked to use a knowledge construction process on this topic (i.e., read aloud text, and/or draw their thoughts). A week later, the individuals were post-tested on the same subject. Using transcribed, audiotaped data, the authors found that teams who interacted more in the knowledge construction process (i.e., increased their shared mental models) were more likely to solve problems (ES_r = .81) than teams who interacted less. Additionally, none of the pairs (teams) correctly solved the blood path circulation problem at pre-test; but at post-test, 50% of the pairs correctly solved the

problem. The authors pointed out a couple of reasons that could explain this finding: (a) Individuals in pairs each generate "part of [stated] inferences to complete the knowledge construction" and (b) after one participant makes an inference, the other partner can "either accept it or reject it" (p. 6). The researchers concluded that "collaborating pairs shared more knowledge (correct and incorrect, stated and inferred) after collaboration" (p. 6). In the perspective of manufacturing, this research suggests that workplace teams with shared mental models are more likely to perform better in solving lean manufacturing problems. If FLSs can engage workers in a team-based knowledge construction process, then the workers' interaction in this process could contribute to the development of a shared mental model.

Similar to Jeong and Chi's (2000) study (which included drawing tasks), the research of Fischer et al. (2002) highlighted the benefits of teams creating visual, concept maps in a knowledge construction process. The authors sought to find out "to what extent collaborative knowledge construction can be fostered . . . [by using] visualization tools as structural support" (p. 213). At the University of Munich, educational psychology students were randomly paired into dyad teams (n = 16). The experimental group used the content-specific visualization tools (i.e., concept mapping tools with built-in content) and the control group used the content-unspecific visualization tools (i.e., concept mapping tools without content provided). Both groups were then asked to solve an evaluation problem that focused on schoolteachers' lesson plans. The researchers found that in comparison to teams who used content-unspecific visualization tools, teams who used content-specific tools developed better quality solutions (ES_r = .65). One reason this occurred, according to the authors, is perhaps the pre-negotiated knowledge construction

structure helped to create "more equal individual gains [i.e., shared mental models] within the dyads" (p. 229). The authors concluded that the content-specific visualization tool "fosters the quality of the collaborative solution to a problem case" (p. 229). In the context of a manufacturing setting, this research supports the notion that workplace teams who build shared mental models around LMP could outperform teams who do not possess shared mental models. Further, the results suggest that if manufacturing workers collaborate in a knowledge construction process, such as creating concept maps with predefined lean concepts (e.g., value stream mapping, setup reduction), then they are more likely to contribute to the development of shared mental models around their problem of practice.

Fischer et al.'s (2002) findings are supported by the work of Okebukola (1992) who also studied the effects of a team-based knowledge construction process. Okebukola had an interest in finding out if a knowledge construction process, such as concept mapping, facilitated team problem solving in science. Pre-degree biology students at the Lagos State University (Nigeria) were asked to participate in this research. In one of the experimental groups participants had six months of team-based concept mapping experience (n = 20). In the control group, participants did not have concept mapping experience (n = 20). All participants were asked to solve three biology problems. Using a qualitative inquiry method, the subjects' written and think-aloud solutions to the problems were audiotaped, transcribed, and scored. The results indicated that the team who had concept mapping experience was more likely to correctly solve biology problems than the team without concept mapping experience (ES_r = .52). The authors suggested that this outcome occurred because the team-based concept mapping

participants "could have had their weaknesses in concept learning and problem solving remedied by more able colleagues and their strengths in these areas, further strengthened" (Conclusion section, para. 7). In other words, a team could be made of members who possess less-developed mental models and receive the greatest benefit of knowledge construction by working with colleagues who have more developed mental models. This sharing of mental models may have played a key role in the team's better performance in problem solving. As applied to the manufacturing setting, this research suggests that workplace teams who possess a shared mental model around lean manufacturing concepts could outperform workplace teams who do not. It also suggests that workplace teams who work together using a knowledge construction process, such as discussing ideas about or mapping ways to reduce waste, are more likely to develop shared mental models.

Expanding on Fischer et al. (2002) and Okebukola's (1992) empirical support for the use of a team-based knowledge construction process, Massey and Wallace (1996) found empirical support for the use of visual mental representations within a team-based knowledge construction process for problem solving. Their goal was to understand the effect of visual representational aids, such as cognitive mapping and influence diagrams, on the facilitation of team problem solving. Students from a university organization behavior class (n = 45) were selected to participate in this mixed methods study. From this sample, 12 teams of three or four students were formed: four teams used the visual, cognitive mapping method (CM), four teams used the visual, influence diagram method (ID), and four teams used the non-visual, brainstorming method. All teams were asked to define the problem evident in a situation that involved excessive alcohol consumption in

a university fraternity organization. The authors were more interested in the knowledge construction process that the CM and ID teams used to define the given ill-structured problem. From a qualitative analysis of videotaped CM and ID team interactions the authors developed a flowchart of the process steps that led to a team problem definition. They determined that six of the eight groups who showed team performance improvements “elected to develop their group visual first and then use it for discussion and development of their respective group problem definition” (p. 266). From additional analysis, two of those six teams were classified as using the *Most Effective Process* (MEP), with an average problem-definition score of 11.75. Four of the six teams were coded as using the *Least Effective Process* (LEP), with an average score of 4.93. The remaining two of the original eight teams were categorized as using an *Ineffective Process* (IP), with an average score of -21.1. The authors suggested that the MEP teams’ success perhaps occurred because “visual representations were . . . used as the common framework through which members interacted . . . as the group worked to a shared visualization [i.e., shared mental models] and, ultimately, a group definition of the problem” (p. 266). Massey and Wallace concluded that “techniques [i.e., visual mental representation methods] that assist individuals and groups in formalizing and making explicit these intricate networks may facilitate the sharing of individual mental representations and the development of a group representation [i.e., shared mental model]” (p. 272). As applied to manufacturing, this research suggests that a team-based knowledge construction process, such as in-depth discussions or the creation of visual representational aids around lean concepts, could contribute to the development of a shared mental model. In addition, this research suggests that workplace teams who have

shared mental models on the process of identifying the real issues, in problematic lean manufacturing situations, are more likely to outperform workplace teams who do not have shared mental models.

In summary, Literature Theme 3 is supported by the research outlined in Table 3, which states that *learning is enhanced when individuals engage in team-based knowledge construction processes*. The theme derived from this research suggests that programs designed to help workers learn how to use LMP would benefit from establishing workplace teams who possess shared mental models, collaborate around a problem of practice, use knowledge-sharing methods, or create visual mental representations of the problem being defined. As applied to a manufacturing setting, FLSs could establish an enhanced learning program to promote a team-based approach for workers to solve lean manufacturing problems. In this program, the focus could be to help workplace teams develop shared mental models around lean manufacturing problems of practice (e.g., how to increase capacity when customer demand surges) as a way to increase their performance. Further, workplace teams could use a team-based knowledge construction process, such as reflective discussions or concept mapping (e.g., linking shared concepts around capacity planning), to develop shared mental models around critical LMP. This research supports Proposition 3 for LMP settings: *Professional learning is enhanced when workers engage in team-based knowledge construction processes*.

Gaps in the Research

Even though the studies shown in Table 1 suggest that learning is enhanced when individuals surface and refine the mental models that guide their work, there are gaps and limitations in this research. Many of the studies were correlational with no cause and

effect established. In addition, the studies were limited to students in secondary or post-secondary settings. Nicoll et al.’s (2001) study was conducted in a university setting, where it included a small number of students. These findings may not generalize to the professional learning of production workers in a manufacturing setting. In addition, Nicoll et al. (2001) used two different professors – one for the treatment group and the other for the control group. This is a limitation because their teaching styles may have influenced the outcome of the study.

The research outlined in Table 2 supports the theme that learning is enhanced when individuals engage in key experiences that increase the complexity of the mental models they use to guide their thinking. There are, however, limitations to the studies discussed here. One concern is the difficulty regarding causal inference in correlational research. The research was also limited to secondary, post-secondary, computer programming, and nursing environments, and may not generalize to manufacturing settings. Another limitation is the small sample size in Wineburg’s (1991) study, which may not be representative of the larger population. Also, there is a threat to internal validity to Ferrario’s (2003) research because of the self-reported data from the survey instrument. Finally, the reliability of causally-supported solutions ($r = .77$) presents a limitation to Barnett and Koslowski’s (2002) study and could influence the repeatability of outcomes.

Although the studies discussed in Table 3 provide support for the theme that learning is enhanced when individuals engage in team-based knowledge construction processes, there are inherent limitations to this research. In Marks et al.’s (2000) study, the external validity is a limitation because they used a low-fidelity tank war-game

simulator that had not been tested in applied settings. In Jeong and Chi's (2000) research, the sample size is small and their findings may not generalize to the university population and other settings. Furthermore, their research is not peer-reviewed, which may reduce the credibility of the study. Finally, the test-retest reliability score ($r = .71$) in Okebukola's (1992) study poses another limitation because the outcomes may not be replicable in other settings, with other populations, and with longer time intervals.

There are gaps in the research about how to best enhance professional learning programs for workers who need to solve lean manufacturing production problems. There are few studies that provide direction for surfacing mental models, refining existing mental models, increasing mental model complexity, and developing shared mental models through team-based knowledge construction processes in a manufacturing setting. This literature review of the research and theory on adult learning provides support for the idea that workers in an enhanced professional learning program can surface and refine mental models that guide their work. These studies, however, do not include workers working in lean manufacturing settings. Similarly, there is evidence to support that an enhanced professional learning program can engage workers in key experiences and that key experiences contribute to increased mental model complexity. Again, the samples in the studies reviewed did not contain workers working in lean manufacturing settings. Finally, there is evidence in the review that an enhanced professional learning program can engage learners in teams in a way that supports team-based knowledge construction processes, where learners develop shared mental models. As with the other studies, these inquiries did not include workers working in lean manufacturing settings. To address these gaps, a research study that was conducted in a lean manufacturing setting could

advance the literature relative to the development and implementation of a professional learning model for manufacturing workers.

Summary

In summary, the Trio Model provided a conceptual framework for this study. The three major components in this model address: (a) individual attributes (includes mental models), (b) key experiences (includes activities that help learners develop complex mental models), and (c) environmental affordances (includes supports). The three literature themes in this study touch on each of the three major components in the Trio Model. Literature Theme 1 (*learning is enhanced when individuals surface and refine the mental models that guide their problem solving*) falls under the individual attributes component, with a specific focus on the individual mental models. In contrast, Literature Theme 2 (*learning is enhanced when individuals engage in key experiences that increase the complexity of the mental models they use to guide their thinking*) is covered under the key experiences component, where these experiences could contribute to increases in the complexity of a learner's mental model. Finally, Literature Theme 3 (*learning is enhanced when individuals engage in team-based knowledge construction processes*) fits within the environmental affordance component, particularly where an enhanced learning program could act as the support system for collaborative teams who engage in knowledge construction. With this conceptual framework, this study was designed to identify the key factors of how workers learned LMP in a specific manufacturing setting as they were experienced by FLSs and first-line workers. A research question was formed to collect qualitative data on what the key factors are in this study's setting and how these factors relate to the research found in the literature themes in this chapter.

Research Question

What did FLSs identify as key factors influencing workers' learning of LMP?

CHAPTER II

Methodology

This study used interpretive qualitative methods (Merriam, 1998) to identify the key factors that influenced how workers learned to use lean manufacturing practices. This chapter describes the methods for sampling, data collection, and data analyses that were used. In addition, the study's limitations and the methods used to enhance the trustworthiness of this study are discussed.

To gain a perspective on the current practices used to help workers learn how to use LMP in a specific manufacturing plant, I employed an interpretive qualitative research methodology (Merriam, 1998), which is widely used in the field of education. The purpose of interpretive research is "knowledge for the sake of knowledge" (Patton, 2002, p. 215). I used this approach because it allowed me to "simply seek to discover and understand a phenomenon, a process, or the perspectives and worldviews of the people involved" (Merriam, 1998, p. 11). According to Patton (2002) interpretive research helps to understand and explain phenomenon within specific disciplines. As applied to this study, the interpretive research methodology provided me an inductive approach to interpret and explain key factors that helped workers learn to use LMP as experienced by this study's participants.

Sample

The sample in this study consisted of six FLSs and two first-line workers who work in different manufacturing cells within the same industrial plant located in the northeast United States. Within this setting, FLSs and workers are required to meet Federal Aviation Administration (FAA) and Occupational Health and Safety

Administration (OSHA) regulations, follow union policies, and adhere to their company's standard work procedures. At the time of this study, it is important to note that downsizing was imminent in this plant. The regulations, requirements, and potential restructuring of this plant, in turn, may have some impact on the results of this study.

FLSs and workers in this plant, which specializes in aerospace product repairs, were eligible to participate in this study if they met the criteria. The criteria were pretty straightforward. If the participant was a FLS, the participant needed to: (a) have at least one year of experience in the current manufacturing cell, and (b) be a direct supervisor of first-line workers. In this study, the FLSs are the primary source of data. This is because FLSs are central to helping workers learn LMP, are closely associated with their workers, and are in a position to assess their skills to know when workers understand the bigger picture of how to implement LMP. If the participant was a first-line worker, the participant needed to: (a) have at least one year of experience in the current manufacturing cell, and (b) report directly to one of the FLSs in this study's setting. The goal was to obtain six to eight participants for this study. Since only six FLSs who volunteered met the criteria for this study, I chose to select two first-line workers to achieve the target of eight participants set for this study and to have their data corroborate the descriptions provided by the FLS participants. This eight-person criteria (a) ensured that I would collect enough information for an "information-rich" study (Merriam, 1998, p. 62) and (b) provided enough data for me to triangulate information from FLS data, first line worker data, and other data sources to reduce threats to trustworthiness.

As a learning and development manager in this manufacturing plant, I had access to FLSs and the workers because their work site was close to my office. However, it is

important to note that I was not their supervisor nor was I involved in their line of supervision.

Table 4 provides a list of the participants involved in this sample (pseudonyms used), their current roles, the number of years they worked in their current roles, and the number of years they worked in the manufacturing industry as current roles. Because the workers in the manufacturing plant are predominantly male, the eight males who participated in the study reflected the workforce involved using LMP. Fuller descriptions of each participant will be provided along with their interview responses in Chapter III.

Table 4

Sample of Participants

Pseudonym	Current role	Years in current role	Years in manufacturing industry as current role
"Peter"	First Line Supervisor 1st Shift	8	8
"Tom"	First Line Supervisor 1st Shift	2	2
"Jerry"	First Line Supervisor 1st Shift	2	3
"Frank"	First Line Supervisor 2nd Shift	2.5	20
"Walter"	First Line Supervisor 1st Shift	2	2
"Larry"	First Line Supervisor 1st Shift	2	4
"Ken"	First-Line Worker	5	33
"Paul"	First-Line Worker	3	18

Data Collection Procedures

The data collection procedures for this study were designed to obtain information to answer the research question stated in Chapter I. These procedures involved a number of steps that included: obtaining permission to conduct the research, communication, invitations, interview schedules, interview preparation, participant interviews, interview transcriptions, and member checking. Following is a description of each step used in the data collection procedure.

Step 1: Permission to Conduct Research

I wrote a letter to the director of the manufacturing plant selected as the setting for this study. In this letter I requested permission to conduct research with FLSs and first-line workers who met the participant criteria. In signing the letter the director gave permission for me to move forward with this study.

Step 2: Communication to Leadership Team

Prior to the formal invitations to the participants, the director of this manufacturing plant sent an email to his leadership team to let them know he approved my research to be conducted in this plant and to be aware that FLSs and selected first-line workers may receive an invitation to participate in this study. The leadership team comprised of the director himself, the business unit managers, the business unit leaders, and the FLSs. Members of the leadership team were not involved in recruiting participants for the study. They did not know the names of the individuals who participated or did not participate in the study.

Step 3: Invitation to Participate in Research

After the leadership team was notified of this study, I emailed an invitation to 17 FLSs to participate in the research (Appendix A). The names of the FLSs were provided to me by the director. Along with this invitation, I sent a brief demographic questionnaire (Appendix B) that confirmed their current role as a FLS and how many years in that role. Six FLSs volunteered to participate in this study; all of whom met the participant criteria. Yet I also wanted to get eight participants overall to ensure data saturation. To achieve this, I extended invitations to workers (Appendix C) within the same manufacturing plant along with the demographic questionnaire. The first two respondents who met the criteria were selected for the study. The FLSs did not know the names of the workers who participated or did not participate in the study.

Step 4: Acceptance to Participate in Research

I notified the eight volunteers, via email, to let them know they met the criteria to participate in this study. In this email, I also let them know that they would be contacted soon to schedule the interview at a time and quiet room most convenient to them (i.e., a time such as lunch time when they were on their own and did not have to make special arrangements to leave the work site). All participants chose to meet in my closed-door office in a separate building where it was quiet and removed from their noisy, busy, and distracting environment in the plant.

Step 5: Participant Preparation for Interview

At least one week prior to the 90-minute interview, I e-mailed the informed consent form (Appendix D) and the interview protocol (Appendix E) to the six FLS participants. I also e-mailed the informed consent form (Appendix F) and the interview

protocol (Appendix G) to two first-line worker participants. Each consent form, approved by the Institutional Review Board (IRB) on July 17, 2008 (see Appendix D and F), outlined the purpose of the interview, the interview format, risks, benefits, reward, personal information protection plan, and contact information.

The interview protocol outlined the questions that were asked in the actual interview. The questions were designed to gather information that would help answer the research question stated in Chapter I. This preparation step gave the participants the opportunity to review and reflect on the questions prior to the interview.

Step 6: Participant Interviews

When participants arrived at my office for the interview at the day and time they chose, I put them at ease by explaining to them the purpose of this study, my role in the doctoral program, and my role as a learning and development manager within their plant. I also had a paper copy of the consent form and the interview protocol for the participants. I reminded them that participation is still voluntary and that they had the right to stop the interview at any time. I also asked them if they had any questions about the consent form or the interview protocol. All participants agreed to continue further with the interview.

The interview protocols were semi-structured, audiotape recorded, and based on a sample interview protocol from the EDLR 304 Experiential Learning course at the University of Connecticut (Sheckley, 2005). The protocols focused on the FLS's and first-line worker's current professional learning practices that linked to surfacing and refining mental models, to engaging in key experiences, and to engaging in team-based knowledge construction processes. During the interviews, participants also described

their view of how the key factors of their professional learning program were linked together.

On average the interview took about 60-90 minutes on average to complete. At the end of the interview, I thanked the participants for their time and for the information they provided. I also told them that I would contact them again for member checking of their transcripts. In return for full participation in the interview, I asked them if they would like to participate in a drawing to receive an online $100 Amazon gift card. All of them volunteered to participate and signed the permission form with their notification preference (Appendix H).

Step 7: Transcriptions of Interviews

I had the audiotapes of each interview transcribed by a professional transcription service who was a preferred and trusted vendor of the company where this study was conducted. The vendor had no contact with the supervisors of the individuals who participated in this study. Transcriptions for all eight participants were provided to me in Word format.

Step 8: Member Checking

All participants received transcriptions of their interviews via email. Participants were asked to review the content for accuracy and were given the option to respond in one of three ways: (a) email, (b) phone call, or (c) meet in person. To complete the member checking activity they were asked to respond with their approval or with any modifications needed to reflect the accuracy of the interview.

The data collection procedure, as described in the eight steps above, was designed to collect thick, rich descriptions (Creswell, 1998) of qualitative data and incorporate

trustworthiness strategies to minimize threats to transferability, credibility, dependability, and confirmability of this research. These strategies will be discussed later in this chapter.

Data Analysis Procedures

In the past two decades researchers have increasingly used software packages so they could analyze qualitative data in a more efficient manner. In turn, this procedure has raised concerns about the impact of such technologies on qualitative data analysis. For instance, researchers have discovered that users of qualitative data analysis software can become too close to the data, get into a data and retrieve cycle, and lose a big-picture perspective (Johnston, 2006). However, with careful use, software programs can help researchers to facilitate the coding and higher-order grouping of codes to develop meaningful relationships for further analysis (Hutchison, Johnston, & Breckon, 2010).

For this study, I used NVIVO10 software to help me efficiently to use the open coding method to capture *in vivo* codes and create categories and themes. According to Merriam (1998) "category construction *is* data analysis" (p.180). It begins with "reading the first interview transcript, the first set of field notes, the first document collected in the study" (p. 181). Open coding, as stated by Thomas (2006), "refers to approaches that primarily use detailed readings of raw data to derive concepts, themes, or a model through interpretations made from the raw data by an evaluator or researcher" (p. 238). Additionally, Charmaz (2006) advises qualitative researchers to categorize, or code, "data *as* actions" because we researchers have a tendency to make "conceptual leaps and to adopt extant theories *before* we have done the necessary analytic work" (p. 48). Miles and Huberman (1994) state that codes are usually "attached to 'chunks' of varying size –

words, phrases, sentences, or whole paragraphs, connected or unconnected to a specific setting . . . . [and] it is not the words themselves but their *meaning* that matters" (p. 56).

Thomas (2006) suggests in open coding, researchers should ask: "What are the core meanings evident in the text, relevant to evaluation or research objectives?" (p. 241). The way I looked at the core meanings was to parcel out special terms (e.g., words, phrases or sentences) from the transcript that could relate to the research question. These special terms were coded as *in vivo* codes, which "help to preserve participants' meaning of their views and actions in the coding itself" (Charmaz, 2006, p. 55).

To give an example of *in vivo* coding, I first looked at the following response from my first participant's transcript for question #7 in the interview protocol:

> Well, each individual has their own way of interpreting what you say. Everybody hears something different. So, what I do, is I have always been more hands on. I will take the employee out and actually show them the situation and what we are in, so we all see and then hear the same thing. That is what I do when we have one big issue but everybody needs to understand what is going on. I take everybody out to the site where the issue happened and you know, explain it to them there, but showing everybody exactly what is going on. So, that is what I do.

After reading this response to get a better understanding of the participant's language, I thought of how this related to research question. This enabled me to focus on the meaning of the participant's response as it related to key factors that influenced how workers learned LMP.

The next step I took was to parcel out words, phrases, or sentences as *in vivo* codes (first column in Table 5) from interview questions that were relevant to the

research question. Each *in vivo* code was identified with the *free node* feature in the NVIVO software.

Table 5

In Vivo Codes from One Participant's Response to One Interview Question

In vivo code	Category
interpreting what you say	interpretations
everybody hears something different	interpretations
hands on	doing job
take the employee out	showing at work site
show them the situation	showing at work site
we all see	showing at work site
hear the same thing	interpretations
everybody needs to understand	interpretations
take everybody out to the site	showing at work site
explain it to them there	focused conversations
showing everybody	showing at work site

After the *in vivo* codes were identified, I read through all the codes to see what was happening and what it all meant. This is because "*in vivo* codes can provide a crucial check on whether you have grasped what is significant" (Charmaz, 2006, p. 57). Using the *in vivo* codes generated, I then created categories (second column in Table 5) with the *constant comparative method* (Glaser & Strauss, 1967). For example, in Table 5, I compared the second *in vivo* code (i.e., "everybody hears something different") with the

first *in vivo* code (i.e., “interpreting what you say”) and found that they were similar in that they both involve a level of interpretation. This similarity caused me to think of “interpretations” as the category to represent both codes. This category was created with NVIVO’s *tree node* feature, which is a higher-order link to the free nodes.

As I moved to the third *in vivo* code (i.e., “hands on”) in Table 5, I then compared this to the prior *in vivo* codes to see if it was similar or different from them. In this case, I found it was different and did not categorize it as “interpretations,” but rather I categorized it as “doing job” given the context in which the words were used. I repeated the process for remaining *in vivo* codes in Table 5 to develop more categories that included “showing at work site” and “focused conversations.” I developed the categories tentatively because my mind needed to be open to possible new categories as I continued to use the constant comparative method down the list of *in vivo* codes. When considered, I used analytical memos to capture my thoughts during the constant comparative process. This is because, according to Charmaz (2006), what “you see in your data relies in part upon your prior perspectives” (p. 54). In addition, I needed to focus on the constant comparative method to help me, as the author states, possibly “gain more awareness of the concepts that [I] employ and might impose on [the] data . . . . [and see] the world through their eyes” (p. 54). By using the constant comparative method, I was able to challenge my personal views and open up more to the participant’s views. Writing analytic memos helped me keep track of my thoughts during the constant comparative method and consequently reduce threats to trustworthiness.

With the constant comparative method, I grouped all the *in vivo* codes from all participant transcripts into categories to begin the process of hierarchical coding. Thomas

(2006) points out in a hierarchical category system, the links “may indicate superordinate, parallel, and subordinate categories” (p. 240). In this study, I created categories that are superordinate to the *in vivo* codes. The categories in this study help to identify specific factors of how workers learned to use LMP. As I progressed with the coding, I reached data saturation after five participants when I saw that no new categories were developed. Data saturation occurs when the data regularities emerge and new codes can be readily categorized (Lincoln & Guba, 1985; Miles & Huberman, 1994; Strauss, 1987).

I then created themes that are superordinate to the categories to help me identify the key factors that helped workers learn how to use LMP as experienced by the participants. Similar to the development of categories, I wrote analytic memos as I developed the themes. For illustration purposes, Table 6 shows how three categories (e.g., focused conversations, information passing, and focused group discussions) were compared to find a higher-order theme of “sharing perspectives,” which came from a small sample of the data set that spanned all eight participants. Once all the themes were identified, I used the themes and categories to help me answer the research question. The presentation of the results will be discussed in Chapter III.

Table 6

In Vivo Codes, Categories, and Themes

Participant	In vivo code	Category (specific factor that helped workers learn LMP)	Theme (general factor that helped workers learn LMP)
“Peter”	explain it to them there	focused conversations	sharing perspectives

(continued)

Participant	In vivo code	Category (specific factor that helped workers learn LMP)	Theme (general factor that helped workers learn LMP)
“Tom”	explain	focused conversations	sharing perspectives
“Jerry”	listening	focused conversations	sharing perspectives
“Frank”	get the facts out there	information passing	sharing perspectives
“Walter”	go over situations with my employees	information passing	sharing perspectives
“Larry”	toolbox meetings	focused group discussions	sharing perspectives
“Ken”	toolbox meeting	focused group discussions	sharing perspectives
“Paul”	he likes to listen	focused conversations	sharing perspectives

Limitations

The data collection and analysis procedures used in this study present some threats to the trustworthiness of the study. Different techniques were used in the data collection and analysis phase to help reduce the threats according to four criteria: (a) transferability, (b) credibility, (c) dependability, and (d) confirmability (Lincoln & Guba, 1985). More information will be given in Chapter III of this study to help readers determine if the results are transferable to their own settings. Audit trails, peer debriefs, triangulation, and subjectivity statements were used to help reduce the threats to

credibility and dependability. Also, to maintain data objectivity, I used a reflective journal to help reduce the threat to the study's confirmability. Table 7 outlines the strategies used to minimize the threats to the current study.

Table 7

Strategies to Reduce Threats to Transferability, Credibility, Dependability, Confirmability

Method	Description
Audit trail	I developed my analytic memos, reflective journal, and transcripts into an audit trail, which can help address potential threats to the dependability and confirmability of this study.
Member checking	I used my prior work experiences at the participant's setting and feedback from the study participants to verify the transcript data. Member checking is a procedure used to confirm the data is accurate, such that the threat to the study's credibility is reduced.
Peer debriefing	I used peer debriefing by obtaining assistance from two of my PhD colleagues, who helped ensure the trustworthiness of the data analysis phase. This strategy can help reduce the threats to dependability and confirmability of this study.
Thick, rich descriptions	I provided thick, rich descriptions of the research participants via their interview responses, data collection procedure, and data analysis procedure. This strategy can help minimize any threats to transferability of this study.
Triangulation	I used different data sources (interview transcripts, memos, and reflective journal) to help triangulate the data. Triangulation can help reduce the threats to the credibility and dependability of this study.
Reflective journal	I maintained a reflective journal of the data collection and analysis phase. This can help to address the threats to dependability and confirmability of the study.

(continued)

Method	Description
Subjectivity statement	I have potential biases that may impact the outcomes of this study. A detailed description of my past experiences, assumptions, and beliefs are discussed in this chapter as a way to reduce the threat to study's credibility.

Subjectivity Statement

According to Merriam (1998) in a qualitative study, the researcher is "the primary instrument for gathering and analyzing data" (p. 20). While it is the responsibility of the researcher to collect and produce meaningful information from the study, the researcher is also "limited by being human" and has "personal biases [that] interfere" (p. 20). These biases are likely to shape the "interpretation and approach to the study" (Creswell, 1998, p. 202). For this reason, I will clarify my biases by sharing past experiences and beliefs that may impact the outcomes of this study. This way, I can manage the threats to the trustworthiness of this study.

As I began my journey in this research, I reflected on my life experiences that have led me to this point and how they have shaped my beliefs and values around learning and development. My mother was a secondary school art teacher for many years and my father loved to learn new things and teach others by nature. My father's sister (i.e., my aunt and Godmother) was a special education teacher for many years in the town I grew up in. My uncle (and Godfather) loved to teach me new things by having me *do* it. My paternal grandmother was a public education teacher for 47 years in the same town. My maternal grandfather displayed a passion for learning well into his nineties. My sister is a former dean of admissions in a small college in Kansas and is currently in the higher

education software industry. My spouse is a former teacher with an art education degree and is currently an editor and instructional designer in the eLearning industry. They all have influenced and shaped my beliefs in learning and development, such that I place great value in learning regardless of what I do or when I do it in life. Because of this value, I am biased to the view that learning is the core foundation of personal and professional growth. In the context of this study, I have the belief that learning is the core foundation for improving lean manufacturing performance.

Aside from being immersed in a family of educators, I engaged in an interesting hobby of magic during my secondary school years. At the time, magic served as an inspirational, and yet challenging, extracurricular activity for me and I was always inspired by magicians who astounded audiences of all kinds. When I reflect on the hundreds of magicians I have watched over the years and all the tricks I used to perform as a semi-professional magician, I was really learning how to solve problems. Magic tricks are really problem solving opportunities in disguise because first, the magician must have a vision of the final effect (e.g., illusion) to produce and second, the magician has to figure out how to make that effect work in front of an audience. As a former magician, I practiced solving magic "problems" repeatedly in order to create the audience effects desired. Over many years in this hobby, magic helped me believe that problems *can* be solved no matter what the desired outcome is or who is solving the problem. Because of this, I believe that FLSs in a manufacturing setting *can* solve lean manufacturing problems despite the level of difficulty.

Along the lines of problem solving, my uncle (retired mechanical engineer and executive) is a strong role model in my life and had indirectly inspired me to pursue a

degree in engineering. He is one who loves to solve mechanical problems by doing his own auto and home repair work. In fact, he taught me how to change an engine block in a 1984 Pontiac Sunbird by having me *do* it, while giving me periodic guidance and feedback. Over the years we developed a kindred bond around how different mechanical objects work. It was this intellectual stimulation that inspired me to gain the skills to solve problems; yet, unknowingly at the time, I was also learning how to learn. Learning how to learn is, I believe, what FLSs need to do, or at least inspire their teams to do the same, in order to continuously improve their lean manufacturing problem solving skills.

Problem solving continued into my undergraduate years, when I pursued my degree in mechanical engineering. After graduating, I spent the next 21 years working for an aerospace manufacturing firm here in the northeast US. While working there, I obtained a master's degree in mechanical engineering and another master's degree in educational technology. The first five years of my career were spent in the engineering department, where I was a full-time designer solving problems related to manufacturing processes, component performance, and overall costs. My engineering years, similar to magic, helped give me the skills to solve problems in a systematic way and gave me the belief that anyone can solve problems if they have the right skills – and this includes FLSs in a manufacturing setting. FLSs can shift their mental models in a way that problem-solving opportunities are viewed as achievable, rather than impossible.

The engineering years prepared me for the next phase of my career. I spent the next 16 years as a technical trainer, instructional designer, training supervisor, training manager, and finally as a learning and development manager in the same company. Similar to engineering, my career in training was fulfilling because problem solving was,

again, a central theme. I picked up more skills by learning how to determine the problems my students faced and how to help them with well-designed training programs. Over the years I became intrigued with how the mind works in terms of learning and memory. This interest led me to the pursuit of a doctorate degree in adult learning. The adult learning program at the University of Connecticut has helped me believe that all FLSs in this study's setting would benefit from any set of activities that helped them understand how adults learn best. This is because I have the assumption that FLSs and first-line workers do not yet understand how adults learn best and how this knowledge can improve their LMP. My hope is that this study will encourage FLSs to identify the current approaches they use to help adults learn and compare these to theoretical best practices of adult learning.

Later in my career as a learning and development manager, much of my time was spent working directly with manufacturing leaders and workers in my company, where the study took place. I engaged in one-on-one coaching sessions with them to help improve their respective team's productivity and safety outcomes. For certain leaders, I developed concept maps to help surface their mental models around a given workplace problem. Those same leaders shared with me that the concept mapping exercises actually helped them clarify their thoughts on how they would approach solving the problem. Because of this favorable experience, I am biased to the idea that concept mapping is one of several best practices of professional learning to use in a lean manufacturing setting.

During my career I witnessed many supervisor practices, including my own. My observations over the years led me to assume that, in this company, most supervisors did not spend the time to carefully plan out key experiences for their first-line workers as part

of a professional learning program. Many supervisors got caught up in the daily "fire-fighting" of tasks and did not make the time to step back and look at the big picture. An important responsibility that was overlooked by supervisors, in my opinion, was the personal development of each first-line worker. Sure, first-line workers got training every year; but, the training often lacked the specific "how to" steps that guide them in their day-to-day responsibilities.

During the period of data collection and as a learning and development manager in this study's setting, I am aware of my own biases for an enhanced professional learning program that could improve LMP. Through the peer debriefing process and documentation of analytic memos, I attempted to identify the impact that my biases had on the data analysis and results in order to reduce the threat to the trustworthiness of this study.

Summary

In this study, I used an interpretive qualitative research methodology to explore and understand the key factors that influenced how workers learned LMP in a manufacturing setting. FLSs in this population face the challenge of enhancing the learning of first-line workers because they find limited guidance in the literature on how to enhance professional learning. The sample was comprised of eight participants (six FLSs and two first-line workers) who worked in the same manufacturing plant. Data collection procedures included a demographic questionnaire and a semi-structured, audiotaped interview. The data were transcribed and loaded into NVIVO10 qualitative analysis software. Data analysis procedures included the identification of *in vivo* codes, development of categories, and the development of themes that helped to answer the

research question. Open coding was used in a constant comparative process for all eight participants to interpret, understand, and explain the key factors of how workers learned LMP in a manufacturing setting. To reduce threats to trustworthiness, I used an audit trail, member checking, peer debriefing, rich descriptions, triangulation, reflective journal, and a subjectivity statement. The presentation of the results is discussed in Chapter III.

CHAPTER III

Results

The purpose of this study was to determine what FLSs identified as key factors that influenced workers' learning of LMP in one specific manufacturing plant within a large aerospace company. The results of this study contribute to a broader effort of enhancing professional learning as it relates to the challenges of implementing LMP in a manufacturing factory. Chapter I described how manufacturing leaders are continually seeking new ways to improve their first-line workers' abilities to implement LMP with a down-sized labor force in a highly competitive global market. As stated in Chapter I, the conceptual framework used for this study is based on key tenets from the Trio Model of Adult Learning (Sheckley et al., 2007). This framework is supported by the three themes from the research literature reviewed in Chapter I: (a) *learning is enhanced when individuals surface and refine the mental models that guide their problem solving*, (b) *learning is enhanced when individuals engage in key experiences that increase the complexity of the mental models they use to guide their thinking*, and (c) *learning is enhanced when individuals engage in team-based knowledge construction processes*.

In this chapter, I present the results of my data analysis from interviews with six FLSs and two first-line workers from a specific manufacturing plant. As outlined in Table 4 in Chapter II, the FLS participants had a range of two to eight years of experience as supervisors in their cell at the time. Similarly, the two first-line worker participants had a range of three to five years of experience as operators in their cell at the time.

This study explored a single research question: What did FLSs identify as key factors influencing workers' learning of LMP?

As outlined in Figure 2, participants identified four key themes that helped them learn to use LMP: (a) Sharing perspectives, (b) Engaging in rich learning experiences, (c) Ongoing support for learning, and (d) Engaging in team-based learning.

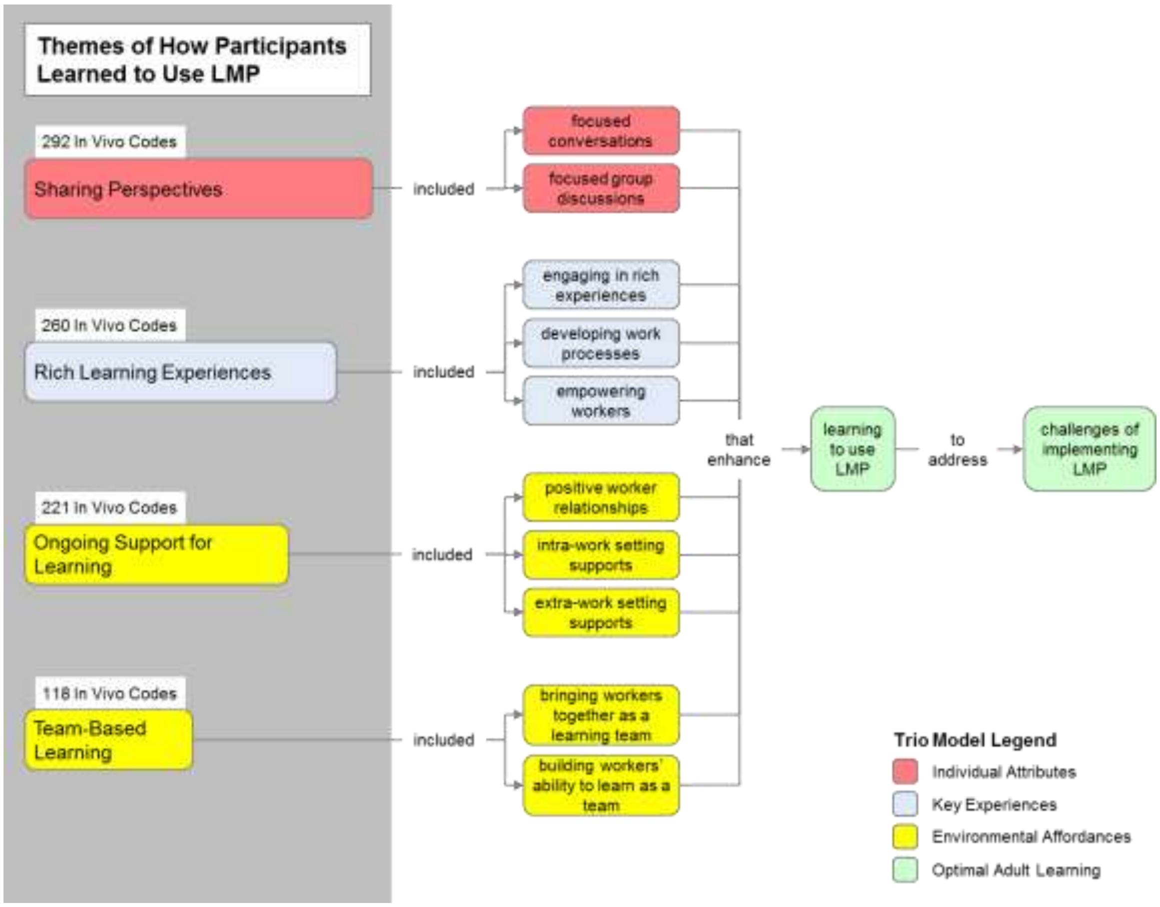

Figure 2. Key themes of how workers learned to use LMP.

Out of approximately 1,400 in vivo codes identified in this study, almost 900 in vivo codes fell into the four major themes identified. The remaining in vivo codes fell into diverse categories of fewer than 100 in vivo codes. Because these categories addressed categories that were not relevant to the RQ (e.g., complaints about management) and because many of these categories had a lower number of in vivo codes (e.g., complaints about management, 16 in vivo codes), they were not included in the final analysis. Instead I focused only on the categories that (a) could generate result

themes of more than 100 in vivo codes and (b) had direct relevance to the research question.

Results Theme 1: Sharing Perspectives (292 In Vivo Codes)

Based on an analysis of data from the interview transcripts, the strongest key factor that helped workers learn to use LMP involved learning through sharing perspectives. The participants in this study described how individual and group conversations that focused on figuring out ways to address the challenges of implementing LMP (i.e., focused conversations) enabled them to learn by sharing perspectives on ways to address the challenges of implementing LMP.

Focused Conversations (207 in vivo codes). In one interview Paul, a first-line worker participant in this study, indicated that focused conversations helped him share any manufacturing “issues that could cause problems or deficiencies” prior to a task. From a broad perspective, he said that, “the ability to voice your opinion [i.e., individual perspective] helps bring out any deficiencies” because identified deficiencies “can be corrected at that time.” When faced with those challenges to implement LMP, Paul felt that “the communication is helpful” and “is very important.” Focused conversations, in essence, were the means to share one’s thoughts or opinions in order to prevent any possible delays or errors in the repair task. Similarly Peter, another of the FLS participants in this study, also indicated that such conversations helped his workers share their own perspectives. When I asked him how he engaged his workers in professional learning activities on the job, Peter said, “Talking with your employees as a group . . . to get everybody’s opinion [i.e., perspectives], to me, helps out the most.” Later in the interview he gave an example of a situation when his cell needed to get certain

“equipment up and running right away,” but it involved “multiple [work] shifts.” To resolve this problem with the use of LMP, he tried to “share knowledge from first shift to second shift” by getting opinions from one shift and “talk[ing] to the next individual [in] the next shift.” It was evident that focused conversations helped Peter’s workers share their knowledge, or perspectives, across multiple shifts in order to bring the equipment back to operational status.

Most of the participants in this study described conversations between the FLSs and workers as a way to share ideas for solving specific production challenges. In my interview with Larry, a FLS participant, he described his approach as more conversational. When asked how he helped influence his workers’ perspectives that guided their work, Larry said in general terms that “it’s more of a conversation.” He described how he began the conversation with questions. For example, he asked his workers, “What do you think if we try this? What happens if we do this?” Later in the interview, he gave an example of when his workers voiced their perspectives on how to improve certain manufacturing tools. Larry continued to explain, “If you ask the employees, they have no trouble at all letting you know what they feel. And sometimes if you don’t ask, they’ll let you know what they feel.” Focused conversations, as evident in Larry’s example, helped his workers share their perspectives around the use of LMP for tooling improvements.

Jerry, another FLS participant, shared a similar view. During the interview, he indicated that conversations helped him get a better sense of his workers’ perspectives. When asked to give an example of an activity that helped his workers share their

perspectives, he could not "think of a particular event." However, to respond to my question in general terms, he said:

> Anything I can think of usually comes from one conversation that I had with an individual employee and, from there, I get an idea of where they are coming from. I mean, you cannot build a perception by seeing someone's actions. However, I think you have much more of an advantage by talking to people.

To have conversations with workers to "get an idea of where they are coming from," as Jerry stated, suggests implicitly that his workers engaged in verbal communication to share their individual perspectives.

When I asked Walter, another FLS participant in this study, how he helped his workers share their perspectives, he said, "You really do have to sit down and let them talk to you and express their feelings, concerns and their ideas." Later in the interview Walter added, "To me, in a work environment . . . communication is key and, also having like an open door system where people can come up to me and talk to me at any time." Although he did not provide a specific example of a conversation, Walter's response demonstrated his openness to verbal communication, where workers can express their perspectives around any work related issues in their manufacturing cell.

Adding to Walter's inputs, another FLS participant, Tom, believed that in order to understand his workers' perspectives of "technical issues out on the floor," he had to have conversations with them. He concluded that, "the only way to extract knowledge or experiences out of someone [is that] they have to feel like they can talk to you." For example, recalling of a time when he had issues with a machine process, Tom set aside time in his routine group meeting to speak with selected workers before they submitted a

job ticket. He said, “It would be like personal time.” During the meeting with his workers, his goal was to “get them communicating with each other on a personal level.” To resolve the machine process challenges, Tom helped his workers verbally communicate their perspectives before implementing the necessary LMP.

Like other FLS participants in this study, Frank held daily conversations with his workers. He said that, “I try to go and speak to them, all of them, every night.” During his conversations he determined if “people [were] having a bad time with something” as it related to their work. For instance, in one of his Kaizen events, Frank described how he talked to a worker who had difficulty moving forward in the process. Through verbal communication, he was able to hear his worker’s perspectives and determine if his worker “did not want” to do the work or “did not know how” to do the work. Knowing this answer was an important step to resolving the challenge of completing the Kaizen event.

When I interviewed Paul and Ken, the first-line worker participants in this study, they indicated that focused conversations with their FLSs helped them share their own perspectives as they related to LMP. For example, when Paul recalled a particular issue with spraying test panels in a plasma booth, he talked with his FLS and found that his leader’s ability to listen was an important part of their verbal communication. He described his supervisor as:

> . . . a very good listener. He listens to what you have to say, and there were a few times or many times that I sat with him and talked to him about a situation or an issue or whatever, he would jot it down on a piece of paper, so to me, you know

> when at least he's jotting it down, it's written down and it is not like just kept in their minds.

In Ken's case, he stated that his FLS "would talk to me and then listen to me." He felt that they "had a good dialogue together." He recalled of a time when focused conversations helped Ken and his colleagues share their perspectives on which equipment to purchase for a particular manufacturing process. Ken added that his FLS was "very communicative" and that he "explained certain pricing and what the budget was." Ken described that the more expensive equipment was what they thought "would be a better piece of equipment" but discovered not necessarily so. He learned that, "sometimes a [less] expensive product does a better job." The focused conversations between Ken, his colleagues, and his FLS helped them to share individual perspectives before purchasing the right equipment for the job.

Focused group discussions (34 in vivo codes). A review of my interview data showed that in addition to focused conversations, focused group discussions also helped participants learn to use LMP by sharing perspectives on ways to address the challenges of using LMP. For example, Tom spoke "to the group to find out who does what and who knows what" in order to solve a machine repair problem. Without group discussions in situations like this, Tom believed that "a lot of knowledge [would not be] shared across the board." This was found to be true for Jerry, too. Jerry discussed shop floor issues with his team in a "kind of an open forum" and attempted to solve these issues by "communicating news" to his workers "that they may not have known."

According to most participants in this study, focused group discussions often occurred in "toolbox talks," which were typically group discussions held on a daily or

weekly basis by the FLSs and their cell workers. For example, Peter led weekly toolbox meetings by "having all the employees together all in one room to discuss the issues." When I asked Peter about what activities helped his workers share their own perspectives, he said:

> I think most areas talk about production and what their methods are, as far as parts. We talk, you know, mostly about safety in different situations that have come up, and reviewing them with both shifts, and sharing comments with both shifts. Those activities I know the employees really like. During those toolbox talks, we talk about all the things that are going on in the shop, things that are being discussed.

Peter's response indicated that a focused group discussion occurred around various topics, with one of them being "all the things going on in the shop." This implies that workers had the opportunity to share perspectives in a group setting, as they related to shop practices. Similarly, Walter led focused group discussions in his cell. In fact, he said, "I constantly use my toolbox [talks]" and that "communication is key" to a successful group discussion around issues related to LMP. Another FLS participant, Larry, also led focused group discussions. He mentioned in his interview that, "We hold our toolbox meeting every week to go over the high level and try to 'air out' everything we need at that time." Larry described how, in these toolbox meetings, they "get quite a bit of good information from them [i.e., first-line workers]." The use of "toolbox" group discussions was repeated in my interview with Frank, who said he held "toolbox meetings and . . . daily conversations with the employees before the start of the shift." Yet in Frank's experience, he focused on small group discussions because he felt that

workers were “more willing to talk to [him] in . . . a group of three or four employees to discuss a problem.” Small or large group discussions, as evident from my participant interviews, enabled workers to share individual perspectives in order to resolve issues related to LMP.

In sum, based on an analysis of the interview transcripts, participants indicated that sharing perspectives via *focused conversations* and *focused group discussions* was a key factor that helped them learn to use LMP. In the next section, I discuss the ways workers were engaged and empowered to participate in learning activities that addressed the day-to-day manufacturing challenges.

Results Theme 2: Engaging in Rich Learning Experiences (260 In Vivo Codes)

My review of the interview data indicated that another key factor that helped workers learn LMP was engaging in rich learning experiences. According to Sheckley and Keeton (2001) “a rich body of experience is essential for learning to occur best” (p. 41). They describe an experience-rich situation (aka “rich experience”) as an event that "(a) enlarges the experience base for reflection (the diversity, not just the quantity, of the base); (b) draws on the natural and primary interests of the learner; and (c) uses unexpected elements of experiences as triggers for questioning previous held ideas" (p. 53). The data suggests in the workers’ rich learning experiences, they had direct, hands-on involvement with problems related to implementing LMP. In turn, this direct involvement enhanced their learning on how to implement LMP within their own manufacturing cell. In many of these rich learning experiences individuals worked through manufacturing problems in a way that empowered them to address more complex challenges of using LMP on their job site.

Engaging in rich learning experiences (107 in vivo codes). When I asked Tom how he gave his workers opportunities to engage in rich learning experiences, he said, "I do not force them to learn. I do not force them to train." Instead, he chose to "explain to them the importance of why they need to do this [task]." Tom felt that if any of his workers "cannot do [the task], we are going to bring in someone else who can." As a supervisor, his "intent [was] for all work to be performed in-house." Later in the interview, I asked Tom to describe an activity in which he engaged his workers in rich learning experiences. He replied:

> I had a situation where a table was off on detail, so they could not make the right cut along the . . . axis and they wanted to bring in an outside mechanical group to come in and tear the machines down and rebuild them and replace parts. I had a problem with that. I thought that with all of the experience that I have in-house and with our other [machine and tool] groups – and speaking with their managers and supervisors on previous occasions – that we should be able to do it in-house.

In this situation, Tom believed that he had "to get the employee engaged and wanting to learn stuff their selves so that no one comes in to do it for them." By engaging his workers in machine repair, Tom helped his workers participate in a rich experience that helped them learn how to address a particular challenge of implementing LMP.

Engaging workers in rich learning experiences was also evident in my interview with Larry. When asked how he engaged his workers in rich experiences that involved learning in job-settings, he replied, "We engage everyone we can, anyone who has a vested interest in what we're doing. We engage them in cell designs, process reviews, [and] any kind of improvements we make to tooling or work instructions or donate

equipment." Larry went on to explain that he always engaged his workers in "decision[s] and any planning" related to "improvements or changes." Their participation contributed to resolving issues around the use of LMP.

Similar to Larry and Tom, Walter made efforts to engage his workers in rich experiences that addressed the implementation challenges of LMP. However, in my interview with him, Walter emphasized a "team" approach to engaging his workers. For instance, when he was asked to describe an activity that helped engage his workers in rich learning experiences, he said:

> I will first ask for volunteers and then, if I know an employee in the past had a bad experience, I would take them to the side and say – especially if I know he would be very good for the Kaizen – I would go sit down and talk to them and tell them to try it out. Let's go through it, it's good for our cell and the team and everything else. I would talk to them like that and get them involved.

As a consequence of this team-oriented approach, Walter described that his workers "were active" participants in a learning activity and that "a lot of their ideas were used" in these Kaizen events.

Like Walter, Jerry emphasized the importance of his "approach" to engaging workers in the first place. When asked in the interview how he engaged his workers in rich learning experiences, he replied, "I have learned to think of the employees, how to approach them on different situations, to get them to engage in any activity that we are trying to perform at that time." Jerry indicated that "one good approach is not for everybody" and learned that he needed to try different approaches in order to engage them in these experiences. Later in the interview, he described how his approach helped

engage his workers to participate in a “multi-Kaizen burst” in order to “redesign the inspection area.” Their efforts contributed to the challenge of implementing LMP to achieve the “ideal [inspection process] speed.”

Peter described a different approach to engaging his workers in rich learning experiences. During the interview, he explained that reinforcing his company’s “cardinal rules” helped engage his workers in the ongoing implementation of safety practices within his cell, such as “lock-out tag-out, machine guarding, [and the securing of] confined spaces.” Peter said that his workers needed “to be aware of [these rules] at different times.” During their annual safety review, he tried to “engage different employees” in order to “get a different cross section of experiences.” Peter explained that “there are a lot of things that we are responsible for on equipment and we pick different techs and mechs to go out there” to address the safety issues. In addition, this meant that when “new equipment” came in to address the safety hazards, the workers needed to “get procedures in place.” Peter added that they are governed by “OSHA” and his company’s “standards” to make sure they had “the right procedures on the machines.” In Peter’s situation, as he described, the workers *had to* participate in this learning experience. He said, “We have to do it and we have to keep our employees safe.” Although enforced in this particular situation, Peter’s workers participated in a rich experience of modifying machines. In turn, the workers contributed to the implementation of LMP because safer equipment and processes meant a decreased risk of delays or work stoppages.

As a first-line worker, Ken felt his FLS helped engage him in “Kaizen events” to improve their work processes. In my interview with him, Ken said, “Our supervisor is very team oriented with us and he does get us to pull together, and asks [for] our input,

and respects our input whether we do that or not." Consequently, Ken participated in the Kaizen events (i.e., rich learning experiences) to establish either better work "flow" or "set up reductions."

Paul, the other first-line worker who participated in this study, also described of an example when his FLS engaged him in a rich learning experience. He said, "One of my activities I have experienced was when the supervisor [was] asking me to engage another employee on working with these certain parts." As a result, Paul participated in a rich experience to help a fellow worker apply a "top coat" and a "bottom coat" to a certain part in order to achieve the correct "thickness." When describing how he helped his colleague, he added, "So for two or three months I was spending time with him, showing him what to do, how to do it, how to come about [with] the answers [for coating thickness]." As evident in both Ken's and Paul's interview, each participated in specific rich experiences that addressed the challenges of implementing or maintaining LMP.

Developing work processes in job settings (95 in vivo codes). Another rich experience that helped workers learn how to implement LMP was the opportunity to develop work processes in job settings. A review of the interview data suggested that to enhance the learning of LMP, FLSs engaged workers in the development of work processes. The rich experience of developing these work processes in job settings helped workers to efficiently address the challenges of implementing LMP.

In Peter's manufacturing cell, there were machines that operated across multiple shifts. Peter believed it was important for his workers to learn how to establish a standard work process for using these machines. In the interview, he indicated that at times the "…machine is down or that it is not working to full capacity." Without standard work, he

believed that “several things . . . can happen.” For instance, if an older machine breaks down, one may discover that “some parts aren’t available anymore.” Or perhaps, in a management team with budget approval authority, “somebody decides that they don’t want to spend the money on the machine.” To minimize the potential of work stoppage or unexpected delays, Peter pushed to “create standard work” and “continue to go in that direction.” He even emphasized that:

> There should be standard work for every part of our system. We don’t currently have that and people in our organization need to understand [i.e., learn] what that standard work is. We don’t currently have that as a process. We are currently trying to work through and I have been pushing, based on my past experiences, on how we should work.

Peter’s experience indicated that the rich experience of creating “standard work” in their own job setting helped workers learn to develop a repeatable and consistent work process. Developing this work process, in turn, helped to improve their understanding of how to implement LMP efficiently in their manufacturing cell.

Tom’s approach to creating a work process aligned with Peter’s. In the interview, Tom described how it was essential to get different perspectives from his workers around certain tasks in order to establish a standard process. He mentioned that, “We need the employees view on this process. The employee may see it differently than I see it because they are actually touching it and actually going out [to assess] the work flow or work scope.” In fact, when Tom took his workers to trade shows, they “looked at different processes, different equipment, and different tools to try and make their job easier, safer, [and] more ergonomically satisfactory.” Later in the interview, he indicated that it was

“very important” that the workers were “part of that process.” As a result of being engaged in the rich experience of creating a work process, workers learned to use a work process that provided an efficient means to handle the challenges of implementing LMP in their own job setting.

While faced with the challenge of performing inspections at a competitive rate, Jerry engaged his workers in the rich experience of “[creating] a process, which led to a VSM [Value Stream Mapping].” As a result of creating a new process, or workflow, his team was “able to create an ideal [inspection] speed and have a world class inspection area as a goal.” As a result of this experience he indicated that his workers learned to use “VSM” and “multi-Kaizen bursts.” In doing so, they were able to provide an efficient way to address the challenges of implementing LMP.

Similarly, the data from Walter’s and Larry’s interviews indicated how engaging workers in the rich experience of using Kaizen events as a work process tool helped advance his workers understanding of using LMP. In fact, Walter said:

> Kaizens are real nice learning tools, ‘cause you pick up things like Value Stream Mapping and everything else like that. And they start to learn the process, not just their process, [but] the process that follows through manufacturing, through my cell, and out to inspection. They learn the whole realm of the process and what other people have to do deal with.

Larry believed that although engaging workers in Kaizen events was helpful, involving workers in the 3P (Production Preparation Process) event was more beneficial to their learning. Reflecting on his experience, he said:

> I think the 3P event was more helpful than some of the Kaizen [events] . . . because with the Kaizen you already have the end results in my mind [and] you already know what the end result is going to be . . . . With the 3P, you kind of know what your end result has to be, it has to be a new cell. But it takes on a life of its own. You see a lot more creativity with the 3P event then you do with a Kaizen event.

Walter and Larry both indicated that the rich experience of learning to use work processes with the help of Kaizen and 3P events helped workers learn an efficient way to address the implementation challenges of LMP (e.g., redesign of a cell).

As first-line workers, both Ken and Paul agreed that the rich experience of helping to improve work processes enhanced their own understanding of LMP and its overall relationship to the manufacturing business. In my interview with Ken, he described a rich experience in which his team was tasked with improving the plasma booth processes. Ken said, "We do what they call 'Kaizen events,' which is basically to improve [a] process, whether it [is] flow, or set up reductions, [or] things like that." In Paul's interview, he talked about an example of a rich experience that involved working with new parts or development parts. He continued to explain that if he could "process parts faster . . . [and] better," then he could "turn around and show others" a new workflow. As described by Ken and Paul their involvement in rich experiences – learning to use work processes with "set up reductions" – enabled them to learn how to create "faster" processes. In doing so, they also learned new ways to address the challenges of implementing LMP.

Empowering workers via rich experiences (58 in vivo codes). Walter was given the challenge of reducing the injury rate in his manufacturing cell. When I asked him how he used rich experiences – a just do it approach – to empower his workers, he said, “It is just empowerment, and getting people involved with it is through the team concept, and getting people to listen to their ideas and let them act on it.” Regarding Walter’s injury rate challenge, he felt the best approach to empower his workers to solve this challenge was to “just get people together and ask them about what their ideas [are] and the best way to fix the problem so [they] won’t get injured again.” In the interview, Walter indicated that his workers participated in a rich experience of “ergo” activities to improve their ergonomic safety.

Likewise in another interview, Peter indicated that he used a rich experience – workers feeling empowered – as a way of empowering his workers to address internal safety issues. Peter commented, “We empower our people to get the job done. Any questions, you know, to come to supervision, but pretty much all our people are empowered to go out there and do the right thing.” For both Walter and Peter, their workers engaged in some rich experiences (i.e., safety learning activities) that addressed the challenge of using LMP to reduce worker injury rates.

As indicated from the discussions of Theme 1, Tom held high expectations for his workers. He expected his workers to “perform to the best of their knowledge and at the top of their game on almost everything” they were assigned. With respect to his workers, Tom said, “If they do not feel that . . . they are capable, you are going to get that type of performance from your employee.” To get the performance expected from his team, he engaged his workers in the rich experience of feeling empowered to develop their sense

of empowerment: “The only way to do that is to empower them and have them have that self-confidence within themselves, [and] that they are making these decisions on what they are doing and how they are going about it.” Similar to Tom, Larry held expectations of his workers. Yet perhaps his approach was a bit softer because he helped empower workers through encouragement. In the interview, Larry described how he encouraged his “employees to take responsibilities, other responsibility for their areas, their work, their tooling, [and] . . . any improvement they can make to tooling.” His emphasis of engaging his workers in the rich experience of feeling empowered was evident when he said, “We are receptive to anything they [i.e., the workers] can offer.” Tom and Larry’s responses suggest that workers who participated in rich learning activities of feeling empowered, in turn, empowered them to address the challenges inherent in implementing LMP.

In my interview with Jerry, he provided a detailed example of how he engaged a worker in the rich experience of feeling empowered as a way to develop the worker’s sense of empowerment. Jerry had a first-line worker who was a “machinist” in one of his cells. This machinist had a desire to be a “lead man, as opposed to . . . just being a machinist.” Jerry explained that the machinist “had no problem with the machine,” but was concerned about him “being tied to the ball.” Jerry decided to set up a rich experience by giving the machinist “more ownership of the cell.” Jerry set up this rich learning experience because the machinist “wanted more of an opportunity of being off of the machine and having more of a high level view of the cell.” Jerry observed, “the cells are functioning better than it ever has.” Jerry felt his strategy worked. By giving the machinist a rich experience of feeling empowered, the machinist embraced more

responsibility within the cell. Eventually he used this sense of empowerment and responsibility to contribute to positive changes in the cell's implementation of LMP.

Ken, as a first-line worker, agreed that his FLS empowered him by providing rich learning experiences on the job. For example, Ken spoke about how his FLS empowered him to deliver "a presentation for the department" about a new metal coating process for his plant. In the presentation, Ken was given the opportunity to "explain the process that [they] were developing and then [transfer] the information to another plant." According to Ken, the Occupational Health and Safety Administration (OSHA) "loved that." He said, "[It] felt very good for me to be empowered to do that. I learned a great deal. I got a lot of respect for it and it came out very nice." Ken was empowered to participate in another rich learning experience in the form of an innovation activity that addressed both process and safety challenges involved in the implementation of LMP.

Overall in this theme, the data analysis showed that workers learned how to implement LMP when they were given the opportunity to be engaged in and empowered by rich learning experiences (i.e., experiences where they had direct, hands-on involvement with the complexities involved in implementing LMP within their own manufacturing cell). As illustrated in the next theme, workers who were learning how to implement LMP also benefited from ongoing supports in their work setting.

Results Theme 3: Ongoing Support for Learning (221 In Vivo Codes)

According to my analysis of the interview data, ongoing support for learning was a key factor that helped workers learn how to implement LMP in their cells. The participants described, in particular, how positive working relationships, intra-work

setting support, and extra-work setting support were strategies that helped workers address the challenge of implementing LMP.

Positive worker relationships (55 in vivo codes). As Walter recalled his experience as a FLS, he described how he developed a “capability of listening” that helped him to “develop a personal relationship” with his workers. He said, “When you develop a relationship with people [i.e., workers] you can actually use that as a tool for motivation.” Walter made the inference that this “tool for motivation” is an ongoing support strategy for job performance and learning.

Like Walter, Larry also made inference to an ongoing support for learning strategy. When asked how he engaged workers in learning how to implement LMP, one of the first things he tried was “to develop a rapport.” He added that “coming from the [shop] floor” he already had a “certain rapport” from the workers. This rapport, as he described, enabled workers to be “receptive” to participation in professional learning activities such as “formal training” or “brainstorming.” Walter and Larry’s view suggests that building positive worker relationships was a strategy that aided their workers’ learning and job performance. With better job performance, it was more likely the workers were able to address the challenges of implementing LMP.

In Frank’s role as a FLS, he built a good working relationship with his workers over time because he earned their trust. He said, “I have developed a reputation where people trust me so they are willing to talk to me or tell me things or ask me questions.” Frank shared an example of when a couple of his workers, who recently faced injuries on the job, opened up to him to “discuss what was causing the injuries.” He believed that in his group of workers, “nobody was afraid to speak up.” During the course of their open

conversations, they were able to come up “with some solutions to the [worker injury] problems [they] were having.” The interview data suggests that Frank had a strategy to provide ongoing support for learning, even in problem situations, because he said:

> They know that if they ask me something it is not going to be a punitive response. We will use it as a chance to either correct the problem that has been made or use it as a learning experience and not to punish.

The trust, openness to talk, and careful avoidance of punitive responses helped Frank maintain a positive worker relationship. In turn, workers were able to address the worker injury issues – being one of the challenges of implementing LMP.

Jerry was a FLS in his cell for only “two and a half years,” but when asked how he engaged workers in learning how to implement LMP, he said it is about “how you approach a person and how the other personality reacts.” He had to learn how to “approach them on different situations.” Jerry said that sometimes it took “more motivational skill” to move workers in a forward direction. He later added, “You [need to] have flexibility . . . [and] have patience as well, whatever it takes to get it working out.” His concern for how to “approach” workers implies that Jerry used a strategy to focus on positive worker relationships as a way to provide ongoing support for workers’ learning.

From a first-line worker’s perspective, Ken reflected on his experiences and said that his FLS had “a nice way of asking for input and help.” Because of his supervisor’s approach to building a positive working relationship, Ken felt it was “hard to say no to him” when asked to, for example, participate in a “Kaizen team” or to “cross-train” in operating a plasma booth. This was an indication that Ken’s FLS fostered a positive

worker relationship with him. For Ken, his FLS' ongoing support for learning strategy seemed to pay off in helping him face the challenges of implementing LMP.

Intra-work setting supports (52 in vivo codes). A review of the participant interview data indicated that FLSs and first-line workers often gave each other support internally (i.e., intra-work setting support) as they faced the challenge of learning how to implement LMP effectively. Jerry felt that, as a FLS, a good strategy was to give intra-work setting support to his workers by being involved with them as they faced challenges on the job. He said, "I feel [that] having the leadership directly involved with the [worker's] activity helps." In one example he recalled, Jerry brought his workers together to resolve an issue with "high dollar" parts that needed to be shipped to their customer. Regarding this issue, he said:

> I could have just said, 'Okay guys, here is your engineer. Fix the problem. Ship the parts. Have fun.' I think they would not have shipped all of those parts. It would not have happened. They probably would have frozen and this would [have] effected [them]. And they would have said, 'I want no part of this.' I think it is important to be a part in this and to be involved in it and letting them know that I am going to be working with them every step of the way if there are issues.

Jerry's decision to "be involved" was a sign of intra-work setting support for his workers as they learned how to implement LMP. This strategy enabled them to ship all the parts successfully, which is a typical challenge that requires the use of LMP.

Giving intra-work setting support to workers as they learned how to implement LMP was also important to Frank. He described how his workers sometimes struggled to do the work because they did "not know how" to do it correctly. In this situation, Frank

said that “we will get them the training, or whatever they need, to do it [correctly].” Frank’s decision, in effect, was an indication of intra-work setting support that his workers needed when they didn’t have the knowledge to properly implement certain LMP. For another participant, Walter, intra-work setting support meant ensuring that workers helped each other out when issues needed to be resolved on the shop floor. In an example he shared about transitioning work from the “first shift” to the “second shift,” intra-work setting support was important for his workers. Walter said that, “when you get that type of team concept, everybody starts to help each other out and start working with each other, and they start learning off each other.” This intra-work setting support served as a strategy to help workers smooth out the shift-to-shift work transitions and improved their ability to use LMP effectively.

While Walter found support between workers was beneficial, Ken described how intra-work setting support also applied to supervisors. For example, Ken (a first-line worker) and his colleagues would occasionally go “on a field trip to go look at the new equipment” to decide which ones to purchase. Ken’s FLS would ask him and the team for their opinions to see if the equipment will do what they are looking for it to do. He said, “It is done as a team and we actually help [the supervisors] decide whether they should buy that or not.” Ken found that his FLS’s strategy to let them provide decision support to supervisors “is very good.” Similarly Paul found satisfaction, as a first-line worker, in giving intra-work support by “training a co-worker.” He said, “If I can teach somebody or show somebody how to do something, I gained some personal experience out of it.” The consequence for Paul’s contribution was a sense of growth and a continuous focus on work quality. He said, “It makes me feel that I can do something to help the cell out and

to ensure that we have a part done correctly." Intra-work setting support, as evident in Ken's and Paul's experience, fits within the ongoing support for learning theme. The data suggests that intra-work setting support was a strategy that helped workers to address the ongoing challenges of implementing LMP.

Extra-work setting supports (114 in vivo codes). Another component to the ongoing support for learning included external supports (i.e., *extra*-work setting support). As they worked to learn how to implement LMP some of the FLS participants, like Peter, Tom, and Larry, found additional support outside of their manufacturing plant. Analysis of the data indicated that extra-work setting support for first-line workers generally came from contractors or vendors who helped provide equipment training or equipment repairs. In Peter's interview, I asked what learning activities were most helpful to his workers and he said, "Well, specific to our trade that I am in . . . is getting key people in, whether it's a contractor [or] the OEM [Original Equipment Manufacturer] for the piece of equipment that we are working on . . . and actually train these folks." Following the training, the workers were "able to go out to the machines and see the equipment to learn [more]." In this situation, external support was a strategy to help Peter's workers meet the challenge of using LMP.

Training from contractors and vendors also helped provide extra-work setting support to Tom's workers. In my interview with Tom, he recalled times when it was "hard to get fellow co-workers to take direction from one of the others who [are] supposed to be doing the same job they are doing." For example, when he needed to fix an electronic board on the shop floor, it was "easier to bring [a vendor] in to use them like a buffer" because the workers tended to "listen to that person easier than they would

[to] the one they worked in-house with." Tom felt that this external support strategy helped put "a stamp on what [his] employee was trying to teach the other employees." Yet his "intent [was] for all work to be performed in-house." In other words, Tom had no intention of bringing vendors in to the manufacturing plant to perform a job that he knew his workers could do, such as repairing one of their axis machines. But he did add that, "I only want to bring in vendors to support or train. I do not want them coming in to do [the workers'] job. That is why they are here." Tom's experience indicates that extra-work setting support (i.e., vendor training) can be a strategy to help workers make progress with the use of LMP.

Like Tom, Larry brought in a vendor to give extra-work setting support when his workers needed to learn how to operate specific equipment. During the vendor's visit, for instance, the workers got to "handle [the equipment] themselves" with the vendor acting "more like a mentor" to the workers. Larry said that the vendor would "give them guidance and work them through some of the issues." As a result, Larry felt that this strategy worked and the workers "retain[ed] much more than the classroom or [than] reading ops sheets or procedures." In turn, his workers became more prepared to handle specific equipment challenges with the use of LMP.

The participant interview data highlighted another form of extra-work setting support. Various professionals, with different levels of job expertise, were often brought in to assist the FLSs and first-line workers on the day-to-day production challenges. For example, in my interview with Frank, he recalled of a "safety related" activity when they "had done some environmental testing and . . . got the results back." With him "being a

lay person," he did "not understand the results" or how to convey the results to his workers. As a solution to this challenge, Frank brought in an expert on safety:

> . . . so I got the safety manager to come and speak to the group. So more or less they got a professional that would understand and could put it into terms that myself and the employees could understand so that we could benefit from it.

In Walter's situation, he was faced with the challenge of having inconsistencies in a particular manufacturing process used in "first shift, second shift, [and] AWW." To address this, he "had an auditor come in" and help him out. The auditor assessed the process and, as a result, he "found a few things that . . . weren't quite right." This showed how Walter used extra-work setting support in the form of an outside expert as an efficient way to address specific process challenges.

Larry spent a tremendous amount of time with his workers to "manufacture 42 carts" for the shop floor. Unfortunately, they discovered that the carts did not work as intended. To solve this challenge, Larry brought in experts outside of his cell to help his team. He said, "The [cart] design wasn't right, so basically we got each employee together, we sat down with them, brought in engineering [and] other management." This resulted in the creation of a new "prototype" cart. Larry's call for engineering job expertise was an example of providing extra-work setting support to efficiently address typical challenges of implementing LPP.

Peter described how he occasionally called in technicians or mechanics, with job-specific expertise, to resolve work order requests. He explained that:

> From the time a job is put into the system, a technician or mechanic will go on that job and check it out. So we'll make the ticket into a work order and go out

> and check out the job and see what it is. If you feel that there [are] a lot of technicians, you will go ahead and get one of the mechanics . . . and go ahead and look at it.

Peter demonstrated how he used extra-work setting support by bringing in additional resources (i.e., technicians and mechanics) to efficiently address the challenge of implementing LMP.

To summarize this theme, the interview data suggests that ongoing support for learning (i.e., positive worker relationships, intra-work setting supports, and extra-work setting supports) are factors that helped first-line workers work well together, help each other out, and with occasional support from vendors and outside experts, learn how to implement LMP. While these practices applied to both individuals and teams, the next theme highlights the importance of team-based learning when implementing LPP.

Results Theme 4: Engaging in Team-Based Learning (118 In Vivo Codes)

The final key theme related to the role of team-based learning in helping workers learn how to use LMP effectively. Whereas the theme "sharing perspectives" discussed earlier related to the learning experiences of individual learners, team-based learning, as described by the participants, involved bringing workers together as a learning team and building a team's ability to learn the best way to work together to address the challenges of implementing LMP.

Bringing workers together as a learning team (66 in vivo codes). Frank recalled a situation when he had to bring his workers together in a room to address mistakes found in work-related documentation that had "to be kept for legal reasons." He discovered that "as time went on" his workers "were making a lot of mistakes in the

documentation." Frank believed that his approach to bringing workers together eventually helped them learn the steps needed to resolve the errors:

> ". . . when we realized [the error] was cross-shifts, it was not just my shift, but [it was also] AWW [Alternative Work Week]. So what we did was, we got every employee that performed that activity. We got them together in a room and we re-conducted the training with different persons doing the training and we also asked the employees what they felt was causing them to make mistakes.

Frank's team-based learning was established by bringing workers "together in a room." This allowed the team to share "what they felt" and ultimately correct the "mistakes in the documentation."

Bringing workers together as a learning team was a routine effort for Peter because he, like other FLSs in this study, conducted weekly "toolbox talks" with his workers. He said, "It is the one day a week that you have everybody together to discuss all our situations." This implies that bringing "everybody together" in a team promoted an opportunity for workers to learn and "discuss [their] situations" (i.e., share perspectives). One of Peter's challenges of implementing LMP was that every day his workers were "all going off in several different directions." Bringing people together as a learning team seemed to help address this challenge.

In my interview with Tom, he described how he was informed that another building "had a breakdown in a machine." The manager of the other building called Tom to "see if [he] had anyone that worked on [this] machinery" because the manager's team "had been working on this for a while and could not get it back up and running." Tom's response was:

> So I just had to ask him if he could come or if he could just send his employees by themselves, the two gentlemen. They had a mechanic and a technical rep to speak with two or three of mine to see if we could come up with something that they could help them do his job.

This showed how Tom brought four or five workers together to establish team-based learning around the machine “breakdown” problem. This gave them an opportunity to learn and “speak” on the issues as a way to “come up with something” that solved the machinery problem.

In Larry’s team, pretty much everything they manufactured was a “custom job.” So it was important for Larry to “know what the end results” were going to be, “what problems have they seen in the past, [and] what problems they expect[ed] to pop up during the process.” He wanted to get a “feel for what [was] going to happen based on the . . . historical data” they had on their parts. This was accomplished when Larry brought workers together to share perspectives, as evident when he said, “We have our meetings. I try to communicate clearly to the employees and they have no trouble reigning me in and telling me where I have something wrong.” When asked for an example, Larry said that his team discussed a “gapping” operation for one of their parts. The “old timers” were used to the “manual” method, which was a “three or four hour operation” and required a “hammer” to complete this. However, others in Larry’s team pushed for the “new piece of equipment” because it “can do all of this in less than an hour.” This team-based learning, as a result of bringing workers together in “meetings,” promoted the team’s ability to learn together and to enhance the shared mental models the team used to

guide its work. In turn, workers addressed the challenge of using LMP to reduce lead-time.

Similarly, Jerry facilitated team-based learning by bringing workers together to resolve issues. For example, Jerry described a time when he needed help to interpret a work order description:

> I took out one of the job folders for one of the jobs out of an envelope. I called the other four to the floor and we opened it up and deciphered it between the five of us so that everyone was aware of what had to be done, what had to be written specifically on the final shipment tag . . . and we resolved the problems that would arise with each inspector.

When Jerry "called the other four to the floor," this demonstrated he brought workers together to form a team. Subsequently this helped workers learn and share perspectives as they "deciphered [the job] between the five" of them. This contributed to their ability to address the challenge of using LMP to deliver parts on time.

Walter described a different kind of challenge when he said that the "first shift was doing things differently than second shift." In his cell, an auditor came in and found things in the work process that were not correct. As a supervisor, he made a key decision to bring workers together:

> . . . we got first and second shift together and AWW, we all went into a room and as a matter fact we even bought them lunch. We sat them down, we had people up on the board, and we came up with what the problems were, what some of the issues were, and as a team came up with good ideas to resolve these issues.

Having "people up on the board" indicated team-based learning. Workers were brought together to share ideas about the "problems" and "issues." As a result, Walter's team helped "resolve these issues [with the use of LMP]."

From a first-line worker's perspective, Ken agreed with his FLS's approach to team-based learning. When asked to give an example, he recalled of a time when they had a quality issue with "test samples" in their cell:

> So we all had a meeting, the whole department did, first and second shift which was good. In fact, first shift got overtime for staying late that is how important the meeting was. Between all of us and all of our ideas, we came up with a solution on why the test pieces were getting contaminated.

This indicates how people were brought together in a "meeting" as a team to talk about their "ideas" on the causes of contamination. When they learned it was due to finger "oils," they "came up with a solution" to wear "PPE [Personal Protective Equipment]," which addressed the challenge of using LMP to maintain quality.

Building workers' ability to learn as a team (29 in vivo codes). Walter found many times in his cell that "a lot of individuals [were] working all by themselves." To have effective team-based learning, he believed in transforming "these individuals into a team" because he saw individuals "struggle" at times to perform their tasks. With building the team's ability to learn together, workers learned to "help each other out." In the interview, he shared his experience of what team building meant to his workers:

> If they know some guy needs a little bit of help to finish the job, they will go over and help them out. If you see someone struggling, loading a part in a machine,

> they actually walk over and help them out. All that just transforms into a very good team relationship.

Walter continued to add that "small groups" of "two people, maybe no more than four," were effective in getting them "talking and feeding off each other." This approach to building team-based learning allowed workers to figure out how to address challenges, such as using LMP to keep a machine in full operation.

When Jerry needed to redesign his inspection area, he began to build the team-based learning process by putting "the team together in a conference room." In there he outlined the work "goal for the week" and each worker's "expectations." Jerry gathered the team "at the end of the day to close out" assigned tasks. Team building with Jerry's workers included efforts to "have a consensus" by those "involved in all the situations." This enabled the workers to learn as a team by sharing perspectives, where they "bounced things off of each other." These perspectives contributed to their ability to implement LMP and work towards a "world class inspection area."

In my interview with Tom, I asked him how he engaged workers in as a learning team that supported a team-based knowledge construction process. He said, "For the most part [of building a learning team], I think, is very important in the sharing of the knowledge and sharing of different techniques in how to do something. I think that is what makes [us] safer and more efficient." While he did not provide a specific example, Tom's response showed an aspect of team-based learning that is consistent with Walter's and Jerry's responses.

Helping individuals work together to learn as a team seemed to be an important responsibility of a FLS, according to Larry's interview data. For instance, he has seen

times when a worker's "major concern" or input was "brushed aside or made light of." Larry believed "if it is important to them, it should be important to you." When I asked Larry how he engaged workers to build their ability to learn as a team, part of his response was:

> Just treat them like humans. If you're concerned for them, [then] they will be concerned for you, and it works out better that way. You spend so much time together [and] it's more than a team. We should be more like family looking out for each other and helping each other.

It was not clear from the interview if Larry fostered the development of a learning team within his cell, but based on his responses in the interview, he indicated it was important for workers to share concerns (i.e., perspectives) because in his mind, "it's more than a team." The implication here, of course, is that team-based learning contributes to better outcomes because "it works out better that way."

The general theme, as described above, highlighted the importance of team-based learning when addressing challenges of implementing LMP. The participants talked about how bringing workers together as a learning team and building the team's ability to learn together as a unit helped them to share different perspectives on the specific manufacturing issues they faced together and, in turn, helped them to learn ways to implement LMP effectively.

Summary of Results

In this study of how workers learned LMP in a manufacturing setting, the four result themes indicated they learned by: (a) sharing perspectives, (b) engaging in rich learning experiences, (c) receiving ongoing support for learning, and (d) engaging in

team-based learning activities. These themes aimed to address the challenges of implementing LMP.

Using the open coding method, the data analysis showed that sharing perspectives was, by far, the strongest theme of how workers learned LMP – as discussed by the participants. The participants described how focused conversations and focused group discussions about workplace issues were the primary means to share individual thoughts and perspectives around the challenges of implementing LMP and thereby enhance each worker's learning.

The second theme of how workers learned LMP included their participation in rich experiences, where they were engaged and empowered in significant experiences such as the development of standard work processes. In turn, the rich experiences helped workers address the challenge of using LMP.

The third theme included ongoing support for the workers' learning as a strategy that helped workers work through manufacturing related issues in a way that enhanced their learning. Participants explained that maintaining positive worker relationships, obtaining intra-work support from colleagues, and getting extra-work support from vendors were instrumental in helping them learn and improve their skills in the resolution of work related issues.

Team-based learning was the fourth theme, in which the study's participants talked about the importance of bringing workers together to share perspectives around the use of LMP as a way to build their capacity to learn together as a team. The four themes, as outlined in this chapter, will be further discussed in relationship to the literature, practice, and future research in Chapter IV.

CHAPTER IV

Discussion, Implications, and Recommendations

In this chapter I discuss (a) how the four result themes (i.e., key factors of how workers learned LMP in study's setting) compare to the Trio Model discussed in Chapter I, (b) implications for practice, and (c) recommendations for future research.

As noted in Chapter III the themes evident in the results suggested that workers, in this study's manufacturing setting, learned to use LMP by: (a) sharing perspectives, (b) engaging in rich learning experiences, (c) receiving ongoing support for learning, and (d) engaging in team-based learning activities. Together these themes aimed to address the challenges of implementing LMP.

The results indicated that there were several characteristics of this corporation that may have contributed to the results. For instance, there was a high emphasis on focused conversations and focused group discussions in this company. Each day there were multiple opportunities for individuals to meet, share perspectives, and learn how to address the issues at hand. Workers participated in job activities within their own cells that provided them rich learning opportunities. This included the rich experiences of creating new standard work processes to ensure consistency and quality in the workplace. They also received ongoing support for learning from FLSs, peers, and outside vendors. In this supportive environment, the FLS and first line worker relationships tended to be positive. Lastly, the participants frequently worked together in teams when they needed to learn how to use LMP to solve manufacturing problems. Based on the results found, the key factors of how participants learned to use LMP were not surprising in this study.

However, what was surprising was that the participants seldom mentioned that these key factors enhanced their proficiency in using LMP.

Discussion of Results Relative to the Literature

In this section I will discuss the four key themes (from Chapter III) as they relate to the Trio Model of Adult Learning. As outlined in Figure 3, the Trio Model depicts optimal learning for adults and involves reciprocal interaction among: (a) individual attributes, (b) key experiences, and (c) environmental affordances.

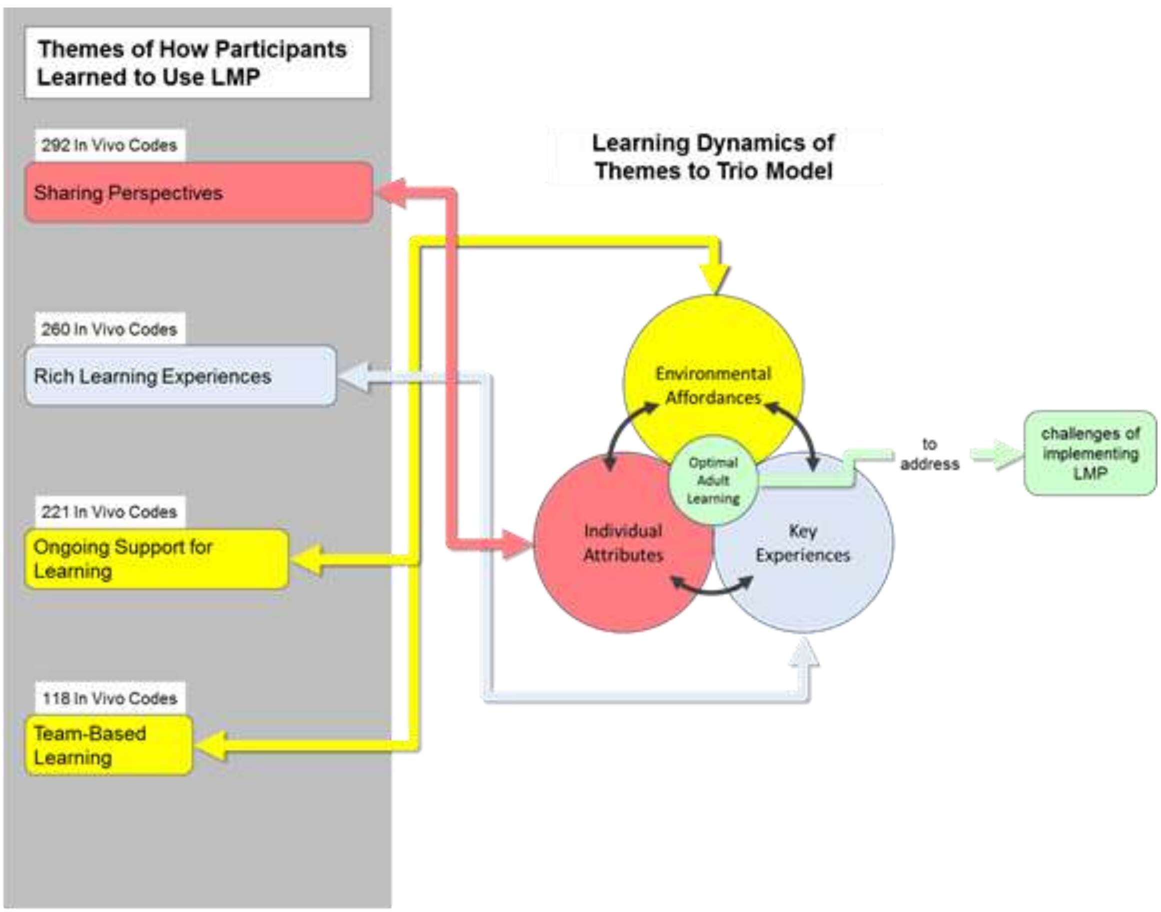

Figure 3. Learning to use LMP: Relationship to components of Trio Model.

The participants in this study highlighted four key themes that helped workers learn how to use LMP: (a) Sharing perspectives, (b) Engaging in rich learning experiences, (c) Receiving ongoing support for learning, and (d) Participating in team-based learning.

These four themes clarify and extend the learning dynamics outlined in the Trio Model. Specifically, the results suggest that workers learning how to implement LMP benefited from a reciprocal interaction between the three components of the Trio Model: (a) *individual attributes* (e.g., sharing their own perspectives with other workers on how to use LMP), (b) *key experiences* that occurred within the workplace (e.g., participation in rich learning experiences such as developing work processes), and (c) *environmental affordances* (e.g., ongoing work setting support for learning and team-based learning). It is important to note that the research in Chapter I involved discussions around mental models, yet understandably the participants did not speak of "mental models" in their interviews. For this reason, I chose to use the term "mental models" when referring to the literature research in Chapter I. In the interviews, however, when participants referred to the term "perspectives," as in the shared conversations that helped them to shift their perspectives, this was their way of talking about the mental models that guided their practice.

Individual Attributes: Sharing Perspectives

As outlined in the Trio Model in Chapter I, mental models are an attribute that individual learners use as they think, reason, and make decisions. Individuals tend to integrate their individual experiences into an amalgam consisting of experience-based perspectives – also called a mental model – that they use to guide their practice. In this study, participants indicated that opportunities to engage in focused conversations and focused group discussions helped them share their individual perspectives with others in a way that extended their understanding of how to address the challenges of implementing LMP.

As an example from Chapter III, Paul indicated that focused conversations helped him share manufacturing “issues that could cause problems or deficiencies” before performing a task. He added that, “the ability to voice your opinion [i.e., individual perspective] helps bring out any deficiencies” related to the task. These “deficiencies” referred to the challenging use of LMP, which he believed could “be corrected at that time.” Paul also felt that “communication is helpful” and “is very important.” This may be because Paul’s own perspective (i.e., mental model) included prior experience relevant to the task at hand. By sharing his perspective (i.e., surfacing his mental model), Paul and his colleagues were able to learn through focused conversations and address the “deficiencies” (i.e., challenges) surrounding this particular task requiring the use of LMP.

Paul’s interview data is in line with the research that supports Literature Theme 1 and the individual attributes component of the Trio Model. For instance one of the studies noted in Chapter I, Nicoll et al. (2001) demonstrated that the process of surfacing mental models (i.e., sharing perspectives) enhanced learners’ problem solving abilities in a freshman-level general chemistry course. The authors determined that students who generated concept maps (i.e., shared individual perspectives) during the course, in contrast to the control group, showed a greater ability to create more chemistry concepts and more useful relationships between those concepts. The researchers concluded that the students in the intervention group were “therefore able to solve more complex problems [i.e., address the challenges]” (p. 1116). This research is similar to Paul’s responses because they both support the view that sharing perspectives (i.e., surfacing mental models) enhances learning.

In another example from the results explained in Chapter III, Larry led group discussions in "toolbox meetings" to help workers share their individual perspectives in order to "air out everything we need" as it related to the use of LMP. In the group discussions, Larry indicated he was able to "get quite a bit of good information" from his workers perhaps because each individual had a different perspective (i.e., mental model) of how to approach the use of LMP. With multiple workers sharing individual perspectives (i.e., surfacing their mental models) with each other, they were able to learn through focused group discussions and provide a variety of "good information" that addressed the challenges of using LMP.

This finding from Larry's data also aligns with the research that supports Literature Theme 1 and the individual attributes component of the Trio Model. For example in Chapter I, I highlighted a study conducted by Stoyanov and Kommers (2006) who found that the new concept mapping method (NCM), when compared to the classical concept mapping method, helped undergraduate students to surface "more and diverse information items [i.e., share perspectives] and more complex labels on the [concept map] links" (p. 311). The researchers believe that concept maps helped represent the individuals' "mental models, [in a way that] . . . problem solver[s] can play with [i.e., refine]" (p. 302). With the NCM, the students produced a variety of information (i.e., a variety of perspectives). In turn these perspectives contributed to "a better approach in [addressing] ill-structured problem situations [i.e., challenges]" (p. 313). Stoyanov and Kommers' (2006) work and Larry's interview data, both suggest that sharing perspectives (i.e., surfacing mental models) enhances learning.

As found from the data results, sharing perspectives is a key theme of how workers learned LMP. This theme is supported by the literature reviewed in Chapter I as well as the individual attributes component of the Trio Model. There is an important difference, however, between the literature and the results of this study. The studies included in the literature review used concept maps to help individuals share their perspectives in a visual format. The participants in this study, however, indicated that focused conversations and focused group discussions were used to help them share perspectives. In either case, the research suggests that sharing perspectives (i.e., surfacing mental models) contributes to their ability to solve problems. In the context of this study, as workers shared their individual perspectives they also increased their ability to address the challenges of implementing LMP.

The results, as discussed in this section, are in line with a body of research that goes beyond the research summarized in Chapter 1. For example, the synthesis of mental model studies conducted by Jones, Ross, Lyman, Perez, and Leitch (2011) emphasizes many of the themes discussed in this section. As an additional and more specific example, Roschelle and Teasley (1995) researched how college students shared perspectives using a coordinated approach to discourses in conversations around a computer-based physics problem. The researchers concluded that this approach helped students "used language and action to overcome impasses in shared understanding [i.e.., via surfacing of their mental models] and to coordinate their activity for mutually satisfactory results" (p. 94).

The question of the best approach to enhance learning by helping individuals surface and examine their individual perspectives – focused conversations vs. visual representations such as concept maps – is an area that could benefit from more research.

Key Experiences: Rich Learning Experiences

As discussed in Chapter I, one of the components of the Trio Model is key experiences. When individuals engage in key experiences, they have the potential to increase the complexity of the mental models they use to guide their thinking. In this study, participants indicated that rich learning experiences on the job contributed to their ability to implement LMP.

As a case in point given in the prior chapter, Tom's workers wanted to "bring in an outside mechanical group to come in and tear the [malfunctioning axis-cutting] machines down and rebuild them." Instead of relying on an outside group, Tom engaged his workers in a rich learning experience by directing them to repair the machines themselves. He believed that "with all of the experience that [he had] in-house . . . . we should be able to do it [i.e., repair the machines] in-house." This could be because Tom was inherently aware that his workers possessed a variety of prior experiences (i.e., a complex network of mental models) that prepared them for this key experience of repairing machines. In turn, Tom may have helped workers further develop their perspectives (i.e., increase complexity of the mental models) that guided their approach to using LMP during operational downtimes.

Tom's responses are aligned with the research that supports Literature Theme 2 and the key experiences component of the Trio Model. For instance, in one of the studies discussed in Chapter I, Barnett and Koslowski (2002) researched the difference between

the key experiences of business consultants and restaurant managers near a small town in upstate New York. The researchers found in their qualitative study that business consultants, when given a hypothetical restaurant business problem, generated more causal reasoning components and causally supported solutions than the restaurant managers. The researchers believed that the business consultants had a broader understanding and an "enhanced theoretical understanding [i.e., developed mental model complexity] [that] is derived from the wide variety of business problem-solving experience [i.e., rich experiences] to which the consultants, but not the restaurant managers, have been exposed" (p. 260). When viewing this research along with Tom's interview data, both suggest that rich learning experiences (an aspect to key experiences component of Trio Model) helped individual learners gain new perspectives (i.e., add complexity to the mental models that guide their thinking) around the use of LMP.

In another example from Chapter III, Jerry described of a first-line worker who was a "machinist" and who had the desire to be a "lead man, as opposed to . . . just being a machinist." Jerry decided to give his machinist the rich experience of being empowered by having "more ownership of the cell." Jerry added that his machinist "wanted more of an opportunity of being off of the machine and [to have] more of a high level view of the cell." The reason for Jerry's decision could be that he felt this rich experience of feeling empowered would broaden his worker's experience base (i.e., build mental model complexity) by embracing new responsibilities and developing a "high level view" of how to use LMP in his cell. This development of a high level perspective (i.e., building mental model complexity) is aligned with the research that supports Literature Theme 2 and the key experiences component of the Trio Model.

For example in Chapter I, Wiedenbeck et al. (1993) examined the performance of expert and novice computer programmers to understand how key experiences guided their work when asked to solve a Pascal programming problem. The researchers found that in comparison to novice programmers, expert programmers had a higher-level view of the problem. In their research, expert programmers also had more variety of key experiences (i.e., rich learning experiences) such as teaching, writing, and maintaining large programs in multiple languages. When solving the Pascal problem, the experts (as compared to novices) more often used hierarchical, layered structures (i.e., high level view) and more often linked variable names to the context in which they appeared. This is because the researchers believed that the experts tended “to seek the relations of objects, which [led] to a connected view of the program [i.e., increased mental model complexity]” (p. 807). This research corroborates with Jerry’s interview data in that they both suggest that higher-level perspectives are linked to a history of key experiences (a component of the Trio Model). In turn, these rich experiences help individuals gain new perspectives about the use of LMP to solve manufacturing problems.

As discussed in Chapter III, one of the key themes derived from participant data is the workers learn how to use LMP by engaging in rich learning experiences related to the implementation of LMP. This theme is supported by the literature research and the Trio Model’s key experiences component.

There was a major difference between the literature and the results of this study in terms of the *variety* of relevant key experiences. For example, in the literature review the experts tended to have more variety of experiences that stretched their understanding of the problem; whereas in the data analysis for this study, the participants’ variety of key

experiences tended to be narrower in scope (i.e., rich experiences within their own manufacturing cell). This study expands on the research in Chapter I because learning experiences have both a depth and breadth. The question of variety of experiences – depth vs. breadth – necessary to enhance learning is a topic that could benefit from more research (Qian, 1999; Schwartz, Sadler, Sonnert, & Tai, 2009).

Environmental Affordances: Ongoing Support for Learning

Environmental affordance is a key tenet of the Trio Model, as outlined in Chapter I. An aspect to this component is the role of support for learners within the setting where they learn. When individuals face challenges, learning is enhanced when those challenges are balanced with support that is tailored to the individual learner's needs (Keeton, Sheckley, & Griggs, 2002). In this study, participants indicated that ongoing support for learning helped them meet the challenge of implementing LMP.

Specifically, the results discussed in the data analysis provided evidence that *intra*-work and *extra*-work setting support provided workers the ongoing support they needed for learning. As an example of intra-work setting support, Walter made sure that workers helped each other out when issues needed to be resolved on the shop floor. There was a challenge he described when workers needed to transition work from the "first shift" to the "second shift." To resolve this, Walter's strategy was to bring his workers together as a team. He said that, "When you get that type of team concept, everybody starts to help each other out and start working with each other, and they start learning off each other." The reason for this "team concept" may be because workers shared a common goal to smooth out the work transition from first to second shift. When workers learned from each other in a "team concept," they developed a shared perspective in an

intra-work setting that addressed the work transition challenge. In Walter's case, intra-work setting support helped to *facilitate* the development of shared perspectives.

In another example from Chapter III, Frank provided his workers extra-work setting support by bringing in a safety expert to help explain the results of "some environmental testing" to them. This could be because Frank did not initially "understand the results" and felt that an outside expert would provide the right level of support to help his workers develop a shared understanding. As a solution to this challenge, the safety expert was able to "put it into terms that . . . the employees could understand [and] . . . benefit from it." The extra-work setting support provided by Frank, in this case, helped to *facilitate* his workers' development of a shared perspective of the environmental test results.

The ongoing support for learning evident in the results of this study is aligned with the research that supports Literature Theme 3 and the environmental affordance component of the Trio Model. For instance, Okebukola (1992) researched the use of team-based concept mapping to solve three problems in a biology course at Lagos State University (Nigeria). The researcher found that the team who had concept mapping experience was more likely to correctly solve biology problems than the team without concept mapping experience. According to the researcher, this could be because the team-based concept mapping participants "could have had their weaknesses in concept learning and problem solving remedied by more able colleagues and their strengths in these areas, further strengthened" (Conclusion section, para. 7). In other words, the "more able colleagues" were providing the ongoing learning support to their respective team members during the concept mapping process. As a result, the team-based concept-

mapping participants developed a shared perspective of the key concepts introduced in the biology course – and ultimately met the challenge of solving the biology problems.

Overall, the data results suggest that ongoing support for learning is a key theme of how workers learned to use LMP. This theme is structurally supported by the literature research and the Trio Model's environmental affordance component. The key difference, however, is in the *way* that ongoing support was provided. For instance, in the literature review, team-based concept mapping activities gave individuals the opportunity to support each other's learning process *visually* as they worked toward a shared understanding. Whereas, the participants in this study indicated that intra-work and extra-work setting support, via team meetings and discussions, helped them learn to use LMP and address the challenges of implementing LMP. In either situation, the research suggests that ongoing support for learning is an environmental affordance for learners. In the context of this study workers were provided ongoing support for learning, either from internal resources or external resources, to address the challenges of implementing LMP. Because businesses need to compete in a global economy, researchers have studied how learning support from distant sites vs. face-to-face meetings effect workers' abilities to solve business problems (Herbsleb & Mockus, 2003; Jonassen & Kwon II, 2001). Perhaps a next round of research could explore the optimal forms of support – support for team-based work activities vs. discussions of visual representations of a problem – that would best enhance learning.

Environmental Affordances: Team-Based Learning

As a continuation of the environmental affordance component of the Trio Model, another type of support for learners is team-based learning. In team-based learning

activities, individuals collaborate around a problem of practice to share individual perspectives and work toward a shared understanding. In this study, participants indicated that team-based learning helped them develop a shared perspective on how to use LMP to solve manufacturing problems.

As an example of team-based learning discussed in the Chapter III, Larry brought his workers together in team "meetings" to share and learn perspectives on a particular "gapping" operation for one of their parts. The "old timers" in the team shared their perspective of using a "hammer," which was a "three or four hour [manual] operation" to complete this. However, other workers in Larry's team shared a different perspective and advocated for the "new piece of equipment" because it can do the same gapping operation "in less than an hour." The reason for this finding could be that Larry knew that his workers had different perspectives and that developing a shared perspective could help his team move forward with a solution. By bringing his workers together as a learning team, Larry gave them the opportunity to learn different perspectives and ultimately develop a shared perspective on how to solve the "gapping" problem. In turn, he also helped his team address a manufacturing lead-time problem – a typical challenge that requires the use of LMP.

This team-based learning is aligned with the research that supports Literature Theme 3 and the environmental affordance component of the Trio Model. As an illustration of bringing people together in a learning team, discussed in Chapter I, Jeong and Chi (2000) found in their research that teams who interacted more in the knowledge construction process (i.e., develop shared perspectives) around a given problem were more likely to solve the human blood circulatory problem. One reason for this finding, as

the researchers explained, was that when a team member makes an inference, another team member can “either accept it or reject it” (p. 6). Going back to Larry’s team, this research may explain part of their learning team process. His workers could have gone through the process of accepting or rejecting their individual perspectives as a way to form a shared perspective around solutions for the “gapping” problem.

In another example, Jerry helped his workers to develop their ability to learn as a team when given the task to redesign his inspection area. Upon meeting in a “conference room” he gave his team the work “goal for the week” and “expectations” for each worker. Jerry led efforts to “have a consensus” (i.e., develop a shared perspective) by team members “involved in all the situations.” Workers were developing their ability to learn as a team because they shared perspectives and “bounced things off of each other.” One reason for this finding could be that the team’s work goals, worker expectations, and sharing of ideas allowed them to adapt to a shared understanding of how to address the inspection area design task. In turn, their shared perspective helped Jerry’s team address production quality – a challenge that often requires the use of LMP.

This finding is supported by the research for Literature Theme 3 and the environmental affordance component of the Trio Model, as discussed in Chapter I. For example, Marks, Zaccaro, and Mathieu (2000) explored how shared mental models contributed to team performance in problem solving. In their research, they found that teams with similar and accurate mental models were linked to better performance. The researchers believed that “a characteristic of adaptive mental models appears to be flexibility, such that teams that are able to shift knowledge structures accurately and in similar ways are likely to be successful in novel contexts” (p. 982). In the case of Jerry’s

team, his team members may have shifted their own knowledge structures (i.e., shared perspectives) at the moment when Jerry provided them work goals and worker expectations.

The data results in Chapter III suggest that team-based learning is a key theme of how workers learned to use LMP. The literature research and the Trio Model's environmental affordance component support this theme. The main difference, however, is the *process* of team-based learning. For example, the literature review examined the use of concept maps as a team-based knowledge construction process to develop shared mental models; whereas, the results from the data analysis indicated that shared perspectives were developed when workers were brought together to learn as a team and hone their abilities to learn as a team. In both cases, the shared perspectives enabled learners to collaborate around a problem of practice. In the context of this study workers engaged in team-based learning in order to address the challenges of implementing LMP. Though the data from Chapter III is aligned with the research outlined in Chapter I, there is an extensive body of research on team-based learning beyond the research discussed in this study. For instance, researchers have examined the relationships between coaching and mentoring and team-based learning (Bolton, 1999; Harrison, Lawson, & Wortley, 2005). Transformational leadership is another area of research that looks at the types of leadership traits that link to better team-learning outcomes (Dionne, Yammarino, Atwater, & Spangler, 2004; Gustafson, 2001). Perhaps follow-up research studies could explore this question more fully: What team-based learning process best helps workers learn how to use LMP?

In summary, the result themes in Chapter III were compared to the literature themes and the Trio Model. The key themes discussed in the results were factors that influenced how workers learned LMP: (a) sharing perspectives, (b) engaging in rich learning experiences, (c) ongoing support for learning, and (d) engaging in team-based learning. These themes are broadly supported by the research in Chapter I and help to extend and clarify the components of the Trio Model. Yet the themes also highlight opportunities to optimize professional learning in a manufacturing setting by increasing the reciprocal interactions between these themes. Implications for practice will be discussed around these interactions in the next section.

Implications for Practice

The challenge that manufacturing leaders face, as discussed in Chapter I, is having workers implement new LMP while under the constraints of a down-sized labor force and increasing competition. FLSs are continually seeking new ways to improve workers' abilities to implement LMP, yet they find limited guidance in the literature on how to enhance workers' professional learning. The purpose of this section is to outline a few implications for practice that could help FLS' enhance professional learning for workers to prepare them for new challenges that require the implementation of LMP.

With guidance from the Trio Model, the results of this study provide a viable framework for enhancing professional learning in a manufacturing work setting. Workers could address the challenges of implementing LMP if FLSs take a more active role, guided by the TRIO model, in changing the work environment that includes a reciprocal interaction between: (a) sharing workers' perspectives on using LMP, (b) engaging workers in rich experiences around using LMP, (c) providing workers ongoing support

for learning how to use LMP, and (d) engaging workers in team-based learning on using LMP (see Figure 4).

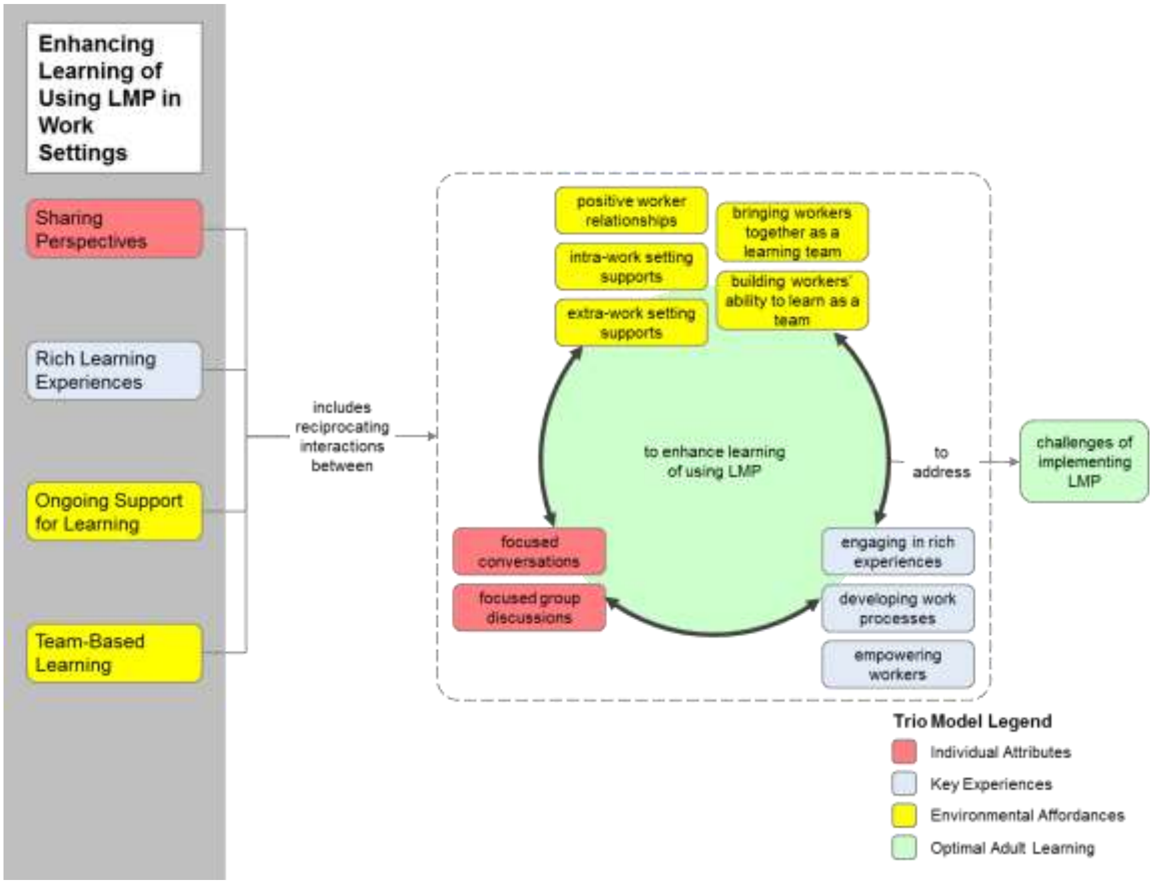

Figure 4. Implications for practice to enhance learning of using LMP in work settings.

Implications for Practice: Sharing Perspectives

Based on my literature research and findings in this study, FLSs could consider activities that help workers to share perspectives around the use of LMP. The literature research supports the sharing of perspectives, as found from those who used concept maps to share concepts related to the problems they solved (Austin, 1993; Bascones & Novak, 1985; Nicoll et al., 2001; Stoyanov & Kommers, 2006; Zittle, 2001). The interview findings revealed that workers shared perspectives by focused conversations and focused group discussions, which are supported by the literature themes and help to extend and clarify the Trio Model. After a careful review of the interview data given in

Chapter III, the implications for practice are for FLSs to: have individual conversations with each worker; engage workers in small group conversations (three or four at a time); engage workers in large group discussions (i.e., "toolbox talks"); and listen to workers and write down notes in their presence.

The main idea, from these implications for practice, is to help workers share perspectives around the use of LMP. Lean manufacturing workers are often exposed to concepts such as 5S events, Kaizen events, Kanbans, pull production, quick changeovers, waste elimination, on-time delivery, and value stream mapping (Worley & Doolen, 2006). However, FLSs could help workers deepen their understanding of the relationships between those concepts by having them share individual perspectives in focused conversations and focused group discussions. As indicated from the research discussed in Chapter I, Nicoll et al. (2001) demonstrated that when students shared their individual perspectives on a problem by creating concept maps, they were "correctly integrating [the chemistry] concepts from different domains into their knowledge structures [i.e., mental models]" (p. 1115). The researchers concluded that the students who had experience sharing perspectives by using concept maps had a complex understanding of the relationships between chemistry concepts and were therefore "able to solve more complex problems" (p. 1116). This research helps to extend and clarify the individual attributes component of the Trio Model. By having workers share perspectives on lean manufacturing concepts, FLSs can help them strengthen their understanding of how to use LMP in more complex manufacturing situations.

Learning to use LMP, via shared perspectives, can also be enhanced if FLSs employ reciprocating interactions with the key experiences and environmental

affordances components of the Trio Model. For example, FLSs can engage workers in different rich learning experiences (key experiences component in Trio Model) such as developing value stream maps and standard work processes. During these rich experiences, FLSs can provide workers internal or external resources (environmental affordances component of Trio Model) to give them the ongoing support needed to implement LMP. In addition, FLSs can engage workers and their support resources in individual, small group, and large group discussions to let them share perspectives (individual attributes component of Trio Model) around how to use the value stream maps and standard work processes. This way, FLSs can enhance the learning process by integrating each component of the Trio Model in order to help them use LMP (e.g., value stream maps and standard work processes) and address the challenges of implementing LMP in more complex situations.

Implications for Practice: Rich Learning Experiences

According to the results of this study and the literature research, FLSs could engage workers in rich learning experiences that involve using and implementing LMP. The literature research supports the learner's participation in key experiences, as found from those who engaged in a variety of rich experiences and associated problem solving activities (Barnett & Koslowski, 2002; Ferrario, 2003; Van Boven & Thompson, 2003; Wiedenbeck et al., 1993; Wineburg, 1991). The interview findings revealed that workers were engaged in rich learning experiences. For example, workers had the rich experience of developing new work processes to help bring a consistent and repeatable approach to performing certain manufacturing tasks. In another example, workers had the rich experience of feeling empowered to take on new responsibilities that centered on

improving production. The rich learning experiences described are supported by the literature themes and they also help to extend and clarify the key experiences component of the Trio Model. After a review of the participant interview data given in Chapter III, the implications for practice are for FLSs to engage workers in rich learning experiences such as: 3P events; cell designs; Kaizen events; value stream mapping events; development of standard work processes; and feeling empowered to take on new responsibilities. Each of these experiences provides opportunities for enriched learning because they engage workers in figuring out ways to translate their ideas into practice. When workers participate in cell designs, for example, they confront the challenge of adapting manufacturing practices to real-time demands of increased quality, better rates of on-time delivery, and reduced costs. As workers confront similar challenges in 3P events, value stream mapping, and developing standard work practices, they learn the intricacies of LMP and how these practices improve manufacturing processes.

There are many more rich learning experiences that can be provided to workers in a manufacturing setting. However, with these implications for practice, the main goal is to empower workers to participate in rich experiences related to using and implementing LMP. Lean manufacturing works best if all workers drive the implementation process and not just the leaders (Radnor & Walley, 2008). FLSs can engage and empower workers to participate in rich learning experiences that help drive the implementation of LMP.

This suggestion is in alignment with the literature research in Chapter I. For example, Barnett and Koslowski (2002) revealed that in comparison to restaurant managers, business consultants demonstrated a greater ability to use *causal reasoning*

and to offer *causally supported solutions* for a given restaurant business problem. The researchers concluded that there was "substantive variability in the consultants' experience [i.e., also referred to as rich experiences], which [was] lacking in the restaurant managers' experience" (p. 262). This research finding supports the key experiences component of the Trio Model. By engaging workers in a variety of rich experiences on using LMP, FLSs can help them gain new perspectives of how to use and implement LMP.

To enhance the workers' learning process for using LMP, via rich experiences, FLSs can employ reciprocating interactions with the individual attributes and environmental affordances components of the Trio Model. For example, FLSs can engage workers in one-on-one conversations, small group conversations, or "toolbox talks" before, during, and after each rich learning experience. The focused conversations or group discussions can help workers share their perspectives (individual attributes component of Trio Model) on how they intend to use or did use LMP to resolve manufacturing problems. FLSs can also engage workers in team-based learning (environmental affordance component of Trio Model) during these rich experiences. For example, Kaizen events, 3P events, and value stream mapping events offer great opportunities for workers to participate in a team-based, rich learning experience. In these events, FLSs could provide teams the workplace goals, expectations, and a frequent schedule to have group discussions. In these "toolbox talks" the teams could close out assigned tasks and share new perspectives regarding their respective lean manufacturing events. By putting more emphasis in the reciprocating interactions between the

components of the Trio Model, FLSs can develop an approach to enhance the learning process and help workers improve on their use and implementation of LMP.

Implications for Practice: Ongoing Support for Learning

Based on the findings in this study, FLSs could provide workers ongoing support for learning how to use and implement LMP. The results from the data analysis suggest that workers will benefit from receiving *intra*-work setting support and *extra*-work setting support. In addition, the data suggest that workers benefit from positive worker relationships between supervision and first-line workers. The findings help to extend and clarify the environmental affordances component of the Trio Model. Based on the results stated in Chapter III, the implications for practice are for FLSs to: build a rapport and a good reputation with workers; become involved with workers in their major work tasks or lean events; encourage workers to help each other out when challenges arise; allow workers to provide decision support to management; and bring in outside resources (e.g., vendors, mechanics, engineers) when workers need assistance.

With these implications for practice, the objective is to provide workers the ongoing support needed to enhance their learning of how to use and implement LMP. If the support leads to a successful implementation of LMP, then manufacturing leaders may experience better relationships with workers on the shop floor (Worley & Doolen, 2006). FLSs can facilitate the intra-work and extra-work setting support that workers need in order to meet the challenge of implementing LMP. As indicated from the literature research discussed earlier in this chapter, Okebukola (1992) found that learners who engaged in a team-based concept mapping activity experienced support from each other as they attempted to solve biology problems. The learners' success may have been

attributed to having "their weaknesses in concept learning and problem solving remedied by more able colleagues" (Conclusion section, para. 7). To put this in another way, the "more able colleagues" helped their respective team members better understand the relationships between biology concepts. As a result, the team received ongoing learning support, which helped them develop a shared perspective of biology concepts and meet the challenge of solving biology problems. This research finding supports the environmental affordances component of the Trio Model. By providing ongoing learning support to workers, FLSs can introduce internal or external resources to help workers develop shared perspectives and ultimately meet the challenges of implementing LMP.

In addition, FLSs can play a role in enhancing the workers' learning process by considering reciprocal interactions with the individual attributes and key experiences components of the Trio Model. For example, FLSs can guide internal resources (e.g., peers) and external resources (e.g., vendors) to engage workers in focused conversations and focused group discussions (individual attributes component of Trio Model) to provide them mentoring support. The purpose of the conversations and group discussions is to help workers develop a shared understanding of how to use and implement LMP around a problem of practice. Based on the results in Chapter III, FLSs can also focus on developing a rapport with workers in order to build a positive working relationship. In turn, this could help FLSs gain the trust from workers and increase their acceptance of participation in rich learning experiences (key experiences component of Trio Model) that they may not have participated in otherwise. With a stronger focus on the reciprocating interactions between the components of the Trio Model, FLSs can work

toward an optimal learning approach that helps workers make progress in addressing the challenge of implementing LMP.

Implications for Practice: Team-Based Learning

From the findings in this study and the literature research, FLSs could engage workers in team-based learning to help them develop shared perspectives around the use and implementation of LMP. The literature research in Chapter I supports the development of a shared perspective in a team-based setting, as found from those who participated in team-based concept mapping activities (Fischer et al., 2002; Jeong & Chi, 2000; Marks et al., 2000; Massey & Wallace, 1996; Okebukola, 1992). The results from the data analysis suggest that workers who are brought together as a learning team, or who build skills to learn as a team, can develop a shared perspective on how to use LMP and address the challenge of implementing LMP. The results are also supported by the research literature themes and help to extend and clarify the Trio Model. Based on the data provided in Chapter III, the implications for practice are for FLSs to engage workers in team-based learning by: bringing workers together for "toolbox talks" in a conference room or at a designated area on the shop floor; bringing workers from all shifts together (e.g., first, second, and third shifts) to address any cross-shift manufacturing issues; building workers' ability to learn as a team through vigilant peer support during times of challenges; building workers' ability to learn as a team through shared perspectives from three or four workers at a time; and building workers' ability to learn as a team through shared respect for other workers' concerns and perspectives.

With these implications for practice, the goal is for workers to develop a shared perspective around the use of LMP for any given manufacturing challenge. FLSs have the

opportunity to guide workers in a team-based setting as they develop a common understanding of how to use and implement LMP. Specifically, FLSs can bring workers together to learn how to use LMP as a team and also help build their ability to learn LMP as a team. Looking back at the research discussed in Chapter I, Massey and Wallace (1996) demonstrated that the teams who had the most effective visual representations were best at defining the problem for a situation that occurred in a university fraternity organization. The researchers suggested that the teams' success occurred because "visual representations were . . . used as the common framework through which members interacted . . . as the group worked to a shared visualization [i.e., shared perspective] and, ultimately, a group definition of the problem" (p. 266). They concluded that the visual representations "facilitate[d] the sharing of individual mental representations and the development of a group representation [i.e., shared perspective]" (p. 272). This research helps to extend and further clarify the environmental affordances component of the Trio Model. By having workers develop a shared perspective around the use of LMP in a team-based setting, FLSs can help improve their understanding of how to address the challenges of implementing LMP.

Along with support for team-based learning, FLSs could continue to enhance learning in the workplace with reciprocal interactions between the individual attributes and key experiences components of the Trio Model. For example, FLSs can continue to have one-on-one conversations (individual attributes component of Trio Model) with workers as they engage in team-based learning. The purpose of the individual conversation is to ensure that each worker has the opportunity to share individual perspectives around the use of LMP. In turn, these same individual perspectives can be

later shared with other workers in future team-based learning activities. According to the results in Chapter III, lean manufacturing activities such as Kaizen events, 3P events, and value stream mapping events are team-based, rich learning experiences (key experiences component of Trio Model). FLSs could encourage workers to participate in different lean events because they offer rich experiences that will enhance their learning of how to use and implement LMP. By concentrating efforts on reciprocating interactions between the components of the Trio Model, FLSs can enhance learning for workers as they attempt to address the challenge of implementing LMP.

Recommendations for Future Research

The current body of research around professional learning in lean manufacturing is very limited. Future research would help determine if the result themes discussed in Chapter III are representative of manufacturing settings across the industry. The FLSs and first-line workers, who volunteered to participate in this study, could be too small of a sample to support a generalized set of findings across the manufacturing sector. So first, I would recommend more research in different manufacturing settings with varying demographics to help establish a generalized view of professional learning approaches used by FLSs and first-line workers in manufacturing facilities.

Second, I would recommend quantitative research involving the key factors discussed in the results of the study. With a quantitative design, future research could explore direct relationships between specific factors (e.g., conversations, group discussions, rapport with workers, participation in a variety of lean events, intra-work support, extra-work support, shared team perspectives) and specific outcomes (e.g., workers' ability to implement LMP). This quantitative research could help other

researchers decide if these factors could apply in other work environments related to the manufactured product’s life cycle (e.g., engineering, customer service, aftermarket services).

Lastly, I would recommend qualitative and quantitative research to test the three propositions stated in Chapter I. For example, qualitative research could help identify other factors that contribute to: (a) the surfacing and refinement of the mental models that workers use to guide their work, (b) the increase in workers’ mental model complexity that guides their work, and (c) the increase in workers’ shared mental models that guide their work. In addition, quantitative research could examine the empirical relationships between the factors discussed in this study (and future studies) and the workers’ abilities to implement LMP.

Final Thoughts

At the time the data were collected for this study, I had the opportunity to work with manufacturing leaders in several factories to discuss ways to implement better learning and development programs. Leaders told me how they were constantly faced with the challenge of reducing lead times, reducing inventory, and increasing production capacity. Sometimes factories lost work to other competitors as a result of not meeting customer demands. Workers were also not given much opportunity to attend training sessions because of their need to stay in the production cells in order to meet customer demand. Those who did attend training were typically the few change agents assigned to the different business units. However, the change agent approach did little to help the factory workers adjust their way of thinking in order to make the necessary strategic and tactical changes to improve production metrics. This situation helped me realize that

something different needed to happen to help enhance learning for the workers *who are on the first-lines of production*. Because first-line workers were mostly influenced by the work directions given by their FLSs, it became clear to me that FLSs were potentially in the best position to enhance their professional learning.

Fast forward to today, I am confident that researchers and practitioners can use the results of this study to advance the literature in adult learning research as it relates to lean manufacturing. This includes exploring how adults: (a) surface and refine the mental models that guide their work, (b) build the complexity of the mental models that guide their work, and (c) develop shared mental models in team-based work activities. The results of this study could also help guide FLSs to develop new professional learning programs that accelerate the development of workers' skills in using LMP in a down-sized labor force and an increasingly competitive industry.

References

Austin, L. B. (1993). Individual differences in knowledge representation and problem-solving performance in physics: Ph.D. dissertation, McGill University, Canada. Retrieved January 20, 2008, from ProQuest Digital Dissertations database. (Publication No. AAT NN87818).

Badurdeen, F., Marksberry, P., Hall, A., & Gregory, B. (2010). Teaching lean manufacturing with simulations and games: A survey and future directions. *Simulation & Gaming, 41*(4), 465-486.

Barker, M. (2011). *Manufacturing employment hard hit during the 2007-2009 recession*.

Barnett, S. M., & Koslowski, B. (2002). Adaptive expertise: Effects of type of experience and the level of theoretical understanding it generates. *Thinking & Reasoning, 8*(4), 237-267.

Bascones, J., & Novak, J. D. (1985). Alternative instructional systems and the development of problem-solving skills in physics. *International Journal of Science Education*, *7*(3), 253-261.

Bolton, M. K. (1999). The Role of Coaching in Student Teams: A" Just-in-Time" Approach to Learning (Vol. 23, pp. 233).

Charmaz, K. (2006). *Constructing grounded theory: A practical guide through qualitative analysis*. London: SAGE Publications Ltd.

Creswell, J. W. (1998). *Qualitative inquiry and research design: Choosing among five traditions*. London: SAGE Publications.

Deming, W. E. (1986). *Out of the crisis: Quality, productivity and competitive position*. Sydney: Cambridge University Press.

Dionne, S. D., Yammarino, F. J., Atwater, L. E., & Spangler, W. D. (2004). Transformational leadership and team performance (Vol. 17, pp. 177-193): Emerald Group Publishing Limited.

Ferrario, C. G. (2003). Experienced and less-experienced nurses' diagnostic reasoning: Implications for fostering students' critical thinking. *International Journal of Nursing Terminologies & Classifications*, *14*(2), 41-52.

Fischer, F., Bruhn, J., Gräsel, C., & Mandl, H. (2002). Fostering collaborative knowledge construction with visualization tools. *Learning and Instruction, 12*(2), 213-232.

Gentner, D., Holyoak, K. J., & Kokinov, B. N. (2001). *The analogical mind*. Cambridge, Massachusetts: The MIT Press.

Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory*. New York: Aldine de Gruyter.

Gustafson, N. K. (2001). *The transformation of leadership behaviors in a manufacturing setting: A correlational case study*. Ed.D., North Carolina State University, United States -- North Carolina. Retrieved from http://proquest.umi.com/pqdweb?did=728446861&Fmt=7&clientId=48996&RQT=309&VName=PQD

Harrison, J., Lawson, T., & Wortley, A. (2005). Facilitating the professional learning of new teachers through critical reflection on practice during mentoring meetings. *European Journal of Teacher Education, 28*(3), 267-292.

Herbsleb, J. D., & Mockus, A. (2003). An empirical study of speed and communication in globally distributed software development. *IEEE Transactions on Software Engineering, 29*(6), 481-494.

Holton, E. F., III, & Baldwin, T. T. (2003). *Improving learning transfer in organizations*. San Francisco: Jossey-Bass.

Hutchison, A. J., Johnston, L. H., & Breckon, J. D. (2010). Using QSR-NVivo to facilitate the development of a grounded theory project: an account of a worked example. *International Journal of Social Research Methodology, 13*(4), 283-302.

Ishikawa, K. (1985). *What is total quality control?: The Japanese way*. Englewood Cliffs, NJ: Prentice-Hall.

James-Sommer, P. (2008). Frontline management training: The lynchpin to business results. Seattle, Washington: Intrepid Learning Solutions.

Jeong, H., & Chi, M. T. H. (2000). *Does collaborative learning lead to the construction of common knowledge?* University of Pittsburgh. Pittsburgh, PA.

Johnston, L. (2006). Software and method: Reflections on teaching and using QSR NVivo in doctoral research. *International Journal of Social Research Methodology*, *9*(5), 379-391.

Jonassen, D. H., & Kwon II, H. (2001). Communication patterns in computer mediated versus face-to-face group problem solving. *Educational Technology Research and Development*, *49*(1), 35-51.

Jones, N. A., Ross, H., Lynam, T., Perez, P., & Leitch, A. (2011). Mental models: An interdisciplinary synthesis of theory and methods. *Ecology and Society, 16*(1). Retrieved from http://www.ecologyandsociety.org/vol16/iss1/art46/

Keeton, M. T., Sheckley, B. G., & Griggs, J. K. (2002). *Effectiveness and Efficiency in Higher Education for Adults*. Dubuque, Iowa: Kendall/Hunt Publishing Company.

Kolb, D. A. (1984). *Experiential learning: experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice-Hall.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Newbury Park, CA: Sage Publications, Inc.

Markman, A. B., & Gentner, D. (2001). Thinking. *Annual Review of Psychology, 52*(1), 223-247.

Marks, M. A., Zaccaro, S. J., & Mathieu, J. E. (2000). Performance implications of leader briefings and team-interaction training for team adaptation to novel environments. *Journal of Applied Psychology, 85*(6), 971-986.

Massey, A. P., & Wallace, W. A. (1996). Understanding and facilitating group problem structuring and formulation: Mental representations, interaction, and representation aids. *Decision Support Systems, 17*(4), 253-274.

Mecham, M. (2004). The lean, green line: Boeing's 'move to the lake' project is downsizing taken to the next level. *Aviation Week & Space Technology, 161*, 144-145.

Merriam, S. B. (1998). *Qualitative research and case study applications in education. Revised and expanded from case study research in education*. San Francisco: Jossey-Bass.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis* (2nd ed.). London: SAGE Publications.

Monden, Y. (1981, January). What makes the Toyota production system really tick? *Industrial Engineering Magazine, 13*, 36-46.

Nicoll, G., Francisco, J., & Nakhleh, M. (2001). An investigation of the value of using concept maps in general chemistry. *Journal of Chemical Education, 78*(8), 1111-1117.

Okebukola, P. A. (1992). Can good concept mappers be good problem solvers in science? *Research in Science & Technological Education, 10*(2), 153-170.

Patel, L. (2010). 2010 State of the Industry Report: ASTD's Definitive Review of Workplace Learning and Development Trends. In A. S. f. T. Development (Ed.). Alexandria, VA.

Patton, M. Q. (2002). *Qualitative Research & Evaluation Methods* (3rd ed.). London: Sage Publications.

Qian, D. D. (1999). Assessing the roles of depth and breadth of vocabulary knowledge in reading comprehension. *Canadian Modern Language Review, 56*(2), 282-307.

Radnor, Z., & Walley, P. (2008). Learning to walk before we try to run: adapting lean for the public sector. *Public Money and Management, 28*(1), 13-20.

Raven, J. C. (1938). *Raven's standard progressive matrices*. London: Lewis.

Robinson, A. G., & Schroeder, D. M. (2009). The role of front-line ideas in lean performance improvement. *The Quality Management Journal, 16*(4), 27-40.

Roschelle, J., & Teasley, S. D. (1995). The construction of shared knowledge in collaborative problem solving. In C. E. O'Malley (Ed.), *Computer-Supported Collaborative Learning* (pp. 69-97). Berlin: Springer-Verlag.

Sala-I-Martin, X., Blanke, J., Drzeniek, M., Geigler, T., & Mia, I. (2011). The global competitiveness index 2010-2011: Looking beyond the global economic crisis (pp. 3-55). Hampshire: The World Economic Forum.

Schwartz, M. S., Sadler, P. M., Sonnert, G., & Tai, R. H. (2009). Depth versus breadth: How content coverage in high school science courses relates to later success in college science coursework. *Science Education, 93*(5), 798-826.

Senge, P. M. (1990). *The fifth discipline*. New York: Doubleday.

Shah, R., & Ward, P. T. (2003). Lean manufacturing: context, practice bundles, and performance. *Journal of Operations Management, 21*(2), 129-149.

Sheckley, B. G. (2005). *EDLR 304 interview protocol*. University of Connecticut at Storrs.

Sheckley, B. G. (2007). *Enhancing the development of educational leaders: Suggestions based on principles of how adults learn best*. University of Connecticut at Storrs.

Sheckley, B. G., & Keeton, M. T. (2001). *Improving employee development: Perspectives from research and practice* (2nd printing ed.). Bloomington, IN: 1stBooks.

Sheckley, B. G., Kehrhahn, M. T., Bell, A., & Grenier, R. (2007). *TRIO model of adult professional learning*: Unpublished manuscript, Department of Educational Leadership, University of Connecticut. Storrs, CT.

Statistics, U. S. B. o. L. (2011). *Productivity and costs by industry: Manufacturing industries, 2009*. Retrieved from http://www.bls.gov/news.release/pdf/prin.pdf.

Stoyanov, S., & Kommers, P. (2006). WWW-intensive concept mapping for metacognition in solving ill-structured problems. *International Journal of Continuing Engineering Education, 16*(3), 297-316.

Strauss, A. L. (1987). *Qualitative analysis for social scientists*. Cambridge, UK: Cambridge University Press.

Thomas, D. R. (2006). A general approach for analyzing qualitative evaluation data. *American Journal of Evaluation*, *27*(2), 237-246.

Tsuchiya, S. (1992). *Quality maintenance: Zero defects through equipment management*. Cambridge, MA: Productivity Press.

Van Boven, L., & Thompson, L. (2003). A look into the mind of the negotiator: Mental models in negotiation. *Group Processes & Intergroup Relations, 6*(4), 387-404.

Wiedenbeck, S., Fix, V., & Scholtz, J. (1993). Characteristics of the mental representations of novice and expert programmers: an empirical study. *International Journal of Man-Machine Studies, 39*(5), 793-812.

Wineburg, S. S. (1991). Historical problem solving: A study of the cognitive processes used in the evaluation of documentary and pictorial evidence. *Journal of Educational Psychology, 83*(1), 73-87.

Womack, J. P., Jones, D. T., & Roos, D. (1990). *The machine that changed the world*. New York: Rawson Associates.

Worley, J. M., & Doolen, T. L. (2006). The role of communication and management support in a lean manufacturing implementation. *Management Decision, 44*(2), 228-245.

Zittle, F. J., Jr. (2001). The effect of web-based concept mapping on analogical transfer: Ph.D. dissertation, The University of New Mexico, New Mexico. Retrieved January 4, 2008, from ProQuest Digital Dissertations database. (Publication No. AAT 3033980).

Zsambok, C. E., & Klein, G. (1997). *Naturalistic decision making*. Mahwah, New Jersey: Lawrence Erlbaum Associates, Inc.

Appendix A

Invitation for First Line Supervisor to Participate in Research Study

Dear (Name of Participant):

My name is Parker Grant and I am the Learning & Development manager for [redacted]. I am also a doctoral student at the University of Connecticut in the Adult Learning Program.

The reason for this e-mail is to personally ask for volunteers to participate in a research study that will examine the current practices of professional learning in your work cell. If you would like to volunteer, please complete the attached demographic questionnaire and forward back to me by [redacted].

If you meet the criteria for the study, you will be invited to participate in the research study. The study would involve a 90-minute interview with me and I will ask several questions about how you help your employees:

1. solve problems
2. describe their ideas
3. get key experiences
4. create knowledge in a team

[redacted], general manager, has given me permission to conduct the study in [redacted]. The study will begin [redacted] and I will contact you to set up our interview date, time, and location that are convenient to you. Before the study begins, you will be given a consent form to read, review, and sign. The consent form will address all issues that will protect you, as a participant, in the study.

Thank you and I look forward to hearing from you soon.

Parker A. Grant

Appendix B

Participant Demographic Questionnaire

Date:

Name (First and Last):

Are you a first line supervisor of a manufacturing cell (circle one)? ☐ Yes ☐ No

Number of years (or months) experience as a first line supervisor in

<u>current</u> manufacturing cell:

Number of years (or months) experience as an employee (i.e., not as a first line

supervisor) in

<u>current</u> manufacturing cell:

Number of years experience in the manufacturing industry:

Number of years experience as first line supervisor in the manufacturing industry:

Appendix C

Invitation for First-Line Worker to Participate in Research Study

Dear (Name of Participant):

My name is Parker Grant and I am the Learning & Development manager for [redacted]. I am also a doctoral student at the University of Connecticut in the Adult Learning Program.

The reason for this e-mail is to personally ask for volunteers to participate in a research study that will examine the current practices of professional learning in your work cell. If you would like to volunteer, please complete the attached demographic questionnaire and forward back to me by [redacted].

If you meet the criteria for the study, you will be invited to participate in the research study. The study would involve a 90-minute interview with me and I will ask several questions about how your first line supervisor helps you:

1. solve problems
2. describe your ideas
3. get key experiences
4. create knowledge in a team

Just so you are aware, your supervisor has also been invited to participate in this study. [redacted], general manager, has given me permission to conduct the study in [redacted]. The study will begin [redacted] and I will contact you to set up our interview date, time, and location that are convenient to you. Before the study begins, you will be given a consent form to read, review, and sign. The consent form will address all issues that will protect you, as a participant, in the study.

Thank you and I look forward to hearing from you soon.

Parker A. Grant

Appendix D

Consent Form for First Line Supervisor Participant in a Research Study

Consent Form for Participation in a Research Study

University of Connecticut

Principal Investigator: Barry G. Sheckley, Ph.D.
Student Researcher: Parker A. Grant
Study Title: Professional Learning and Lean Manufacturing

Introduction

You are invited to participate in a research study to tell how you help employees learn and solve problems. You are being asked to participate because you are a first line supervisor.

Why is this study being done?

The purpose of this research study is to find out how you help employees learn and solve problems. The study will help managers make a better learning program for supervisors to use and follow.

What are the study procedures? What will I be asked to do?

There are four parts to the research study. The first part was the survey and the second part is the interview. The third part is a review of your interview responses. The fourth part is another interview to review your documents.

1. You completed a survey that asked for your name and experience. To be in the study, you needed to have at least 12 months of supervisor experience in your work cell. As a result of the screening [redacted] will be in the study.

2. You will be asked to take part in an interview. The interview will last about 90 minutes long. The interview will be in a private room either in your building or in the [redacted]. The researcher will ask for your permission to digitally record your voice in the interview. This will help us get your information correctly. If you do not feel comfortable at any time in the interview, you can stop the interview and the voice recording.

   The interview questions will ask about how you help employees:
   - solve problems
   - describe their ideas
   - get key experiences
   - create knowledge in a team

This interview will take place in [redacted]. During the interview the researcher will ask for copies of documents. These documents will relate back to some of your interview responses. For example, the documents could be value stream maps, process maps,

root cause diagrams, etc. You can give these documents to the researcher in the next interview (part 4).

1. About 2 weeks after the interview, you will be given a typed copy of your responses. At this time, you will have the chance to review your responses to be sure they are correct. Your review will take about 30 minutes. Then you can give the researcher all corrections in an email, phone call, or in person at your convenience.

2. About 1-2 weeks after the interview, the researcher will interview you in person again. This time the interview will be about 30 minutes long and will focus on your documents.
   a) The interview will be in a private room either in your building or in [redacted].
   b) The researcher will not digitally record your voice in the interview.
   c) If you do not feel comfortable at any time in this interview, you can stop the interview.
   d) Before you give copies of the documents to the researcher, you will need to black out all names on the copies. This way, the researcher will not know the names written on the documents. This will help protect the identity of the people whose names are on the documents.

Also, the researcher will need to interview one or two of your employees. First, you will be asked to provide all of their names. Next, the researcher will send an e-mail invitation to each employee. From those employees who volunteer to interview, one employee will be chosen. If needed, a second employee will be chosen. Criteria will be used for choosing the employees to interview. The employee needs to have 12 or more months experience in your work cell.

In their interviews, the employees will be asked how you help them: The employee needs to have 12 or more months experience in your work cell

- solve problems
- describe their ideas
- get key experiences
- create knowledge in a team

What are the risks or inconveniences of the study?

We believe there are no risks to you for your participation in this research study. A possible inconvenience may be the time it takes for you to complete the study.

If you are not comfortable with any interview question, you can choose not to answer it.

What are the benefits of the study?

You are not expected to benefit from this research; however, we hope that your participation in the study may advance the knowledge of how adults learn in a production factory. The researcher will use the findings from this study in the context of his position at the company. The study will find out how first line supervisors help employees learn. The findings could help learning managers build a better

employee learning program. As a result, this new learning program could help improve lean production.

Will I receive payment for participation? Are there costs to participate?

There are no costs to participate in this study.

After the study, you have the choice to enter a drawing to win a $100 gift. If you win, you will get an Amazon.com gift certificate. This will come to you in an email address you give.

However, you will not be allowed to enter the drawing if you do not finish the study.

If you want to enter the drawing, you will complete an information card. You can do this at your interview. The card will ask for your name and how you would like to be notified of your win (for example, email, phone call, or internal mail). On the card, you will also be asked to give your preferred email address to get the online gift certificate.

All of the participants who choose to enter the random drawing will have their cards placed in an empty box. The box will be shaken and the student researcher will reach into the box and pick one card. The chosen card will be the winner of the gift certificate.

The drawing will take place by no later than [redacted]. Only the winner will be notified of the results.

How will my personal information be protected?

The procedures below will help make your data confidential.

1) The researchers will keep all study records locked in a secure location. This includes any codes to your data. The study records will be locked in the [redacted].
2) Research records will be labeled with a code. The code will be made from [redacted]. [redacted].
3) A master key that links names and codes will be locked in the [redacted]. The master key will be [redacted].
4) Your digital voice records from the interview will be typed up by a company that is hired by your company. The digitally recorded audio tapes themselves will not be shared with management or FLSs. The voice records will be [redacted].
5) All electronic files that identify you will be locked with a password. The files include databases and spreadsheets. Any computer that hosts these files will also be locked with a password. These files will be on the [redacted]. [redacted] have firewall and password protection. Only the members of the research staff will have access to the passwords. The data will be kept indefinitely. [redacted].
6) Data that will be shared with others will be coded with [redacted]. This method will help protect your identity.

1) At the conclusion of this study, the researchers may publish or present their findings. The findings will be in a summary form.
   a) The findings may be given to the management team in your company. However, your name will not be given to the management team. The findings will not expose you to the risk of being identified. The findings will help the management team decide on a new learning program for you and the company.
   b) The findings may be presented at a conference. However, your name will not be given at the conference. The findings will not expose you to the risk of being identified. The findings will help managers in the training industry improve their learning programs. Your company's publication release policies will be followed.
   c) The findings may be published in an article or a book in print or on the Internet. However, your name will not be given in the article or the book. The findings will not expose you to the risk of being identified. Also, your company's publication release policies will be followed.
   d) The answers you give in the interview may be quoted. The quotes may be direct or indirect in the summary. The quotes may also be paraphrased in the summary. However, your quotes will not expose you to the risk of being identified. For example:
      i) If you mention of doing a particular task that no one else does, this task will be removed from the summary.
      ii) If you mention the name of your work cell, this name will be removed from the summary.

The student researcher is also an employee of your company. If you made a violation and tell about it in the interview, it may need to be reported. The situations below will NOT help make your data confidential.

- You violate your company's code of ethics and tell about it in the interview. In this case the student researcher may need to report it to your management.
- You violate your company's policies and tell about it in the interview. The student researcher may need to tell this to your management.
- You violate the law and tell about it in the interview. The student researcher may need to tell this to your management.

You should also know that the UConn Institutional Review Board (IRB) and the Office of Research Compliance may inspect study records as part of its auditing program, but these reviews will only focus on the researchers and not on your responses or involvement. The IRB is a group of people who review research studies to protect the rights and welfare of research participants.

Can I stop being in the study and what are my rights?

You do not have to be in this study if you do not want to. If you agree to be in the study, but later change your mind, you may drop out at any time. There are no penalties or consequences of any kind if you decide that you do not want to participate.

For the survey or for the interview, you do not have to answer any question that you do not want to answer.

At any time you may be withdrawn from the study if you miss more than one appointment. You may also be withdrawn if you do not follow the interview process or if you have adverse reactions.

Who do I contact if I have questions about the study?

Take as long as you like before you make a decision. We will be happy to answer any question you have about this study. If you have further questions about this project or if you have a research-related problem, you may contact the principal investigator, Dr. Barry Sheckley at [redacted] or the student researcher, Parker Grant at [redacted]. If you have any questions concerning your rights as a research subject, you may contact the University of Connecticut Institutional Review Board (IRB) at [redacted].

Documentation of Consent:

I have read this form and decided that I will participate in the project described above. Its general purposes, the particulars of involvement and possible hazards and inconveniences have been explained to my satisfaction. I understand that I can withdraw at any time. My signature also indicates that I have received a copy of this consent form.

______________________	______________________	__________
Participant Signature:	Print Name:	Date:
______________________	______________________	__________
Signature of Person Obtaining Consent	Print Name:	Date:

Appendix E

First Line Supervisor Interview Protocol

Part 1. Introduction and Interviewee Signed Informed Consent.

Good afternoon/evening. My name is Parker Grant. Before we begin, I would like to thank you for taking the time to talk with me today.

I am working on a research project for my dissertation in the Adult Learning Program at the University of Connecticut. We are interested in knowing more about how adults learn in a lean manufacturing setting.

During the next 1.5 hours or so, I will ask you some questions about your own professional learning practices. I'd also like your consent to tape-record your response so that I may review your words at a later time.

Let me emphasize one point: If you are uncomfortable with any aspect of the interview, please feel free to say so. We can stop the tape recorder or the interview at any time you wish. No explanations required.

Do you have any questions at this point? ____

If you are agreeable to proceeding with the interview, I would like to ask you for your signed consent at this time. Your signature on the consent form indicates that you have a general understanding of what your participation in this study involves and that you willingly consent to participate.

OK? Ready to begin? ____

Now that the tape-recorder is on, please state your name, the date, and that you consent to have your response tape-recorded. ___________________________________
____

Part 2: Background Information.

Operational Definition of Professional Learning:

Professional Learning is *any* activity that contributes to learning within the learner's profession. Examples of professional learning activities include job assignments, formal training, informal training, team-based projects, etc.

1. To begin, would you tell me a bit about your prior work experience? __________

2. During all of your years as first line supervisor what type of capabilities have you developed in engaging employees in professional learning activities? ____

3. Any others? ____

4. To what extent do you engage employees in professional learning activities?
[Use a scale of 1 – 7, with 7 being "fully engage" and 1 being "do not engage"]

5. OK. Let's talk a bit more about the extent you engaged employees in professional learning activities…

   Reflect for a moment on the professional learning activities in which you engaged your employees…

   Describe a professional learning activity in which you engaged your employees when the situation required you to do so. __________________________

6. Think in broad terms of experiences, relationships, key activities, critical events, and the like. No need to confine yourself to classroom-type events. From this broad perspective, what professional learning activities were most helpful for your employees and why? ____

Part 3: Mental Models.

Operational Definition of Mental Model:

A learner's mental model represents his/her view of how the world works. It influences how the learner understands the world and how he/she takes action (Senge, 1990). In the context of this study, learners use their mental models to guide their work.

Example of Mental Model from:
http://www.boxesandarrows.com/view/whats_your_idea_of_a_mental_model_

"If I tell them that I recently ordered a steak at a restaurant, they might assume that I was met at the door by a host or hostess, seated, and presented with a menu. They assume these details, and others, that I never actually mentioned because they have a mental model of how restaurants operate. To illustrate the consequences of having a mismatched mental model, I describe a person who goes into a buffet restaurant and waits for someone to take their order. The person's mental model of how that restaurant operates doesn't match the actual situation, and he would experience confusion and frustration until he modified his original model to include buffets."

7. In your role as first line supervisor, what type of capabilities have you developed in understanding your individual employee's mental model that guides his/her work? ____

8. Any others? ____

9. To what extent do you help bring an individual employee's mental model to the surface when the situation required you to do so?
[Use a scale of 1 – 7, with 7 being "full extent" and 1 being "no extent"] __________

10. OK. Let's talk a bit more about the extent you brought your individual employee's mental model to the surface…

    Reflect for a moment on the activities in which you helped surface your employee's mental model…

    Describe an activity in which you helped your individual employee (directly or indirectly) surface his/her mental model when the situation required you to do so. ____

11. From a broad perspective, which activities were most helpful for your individual employee and why? ______________________________

12. In what ways do you help your employee build upon his/her current mental model that guides his/her work? ______________________________

13. What documents are you willing to share that support any of the activities you described above? ______________________________

Ask for copies of these documents.

Part 4: Key Experiences.

Operational Definition of Key Experience:
Key experiences for learners are rich, multi-faceted, and wide ranging (Sheckley, 2007). In the context of this study, learners learn from transforming experiences into knowledge (Kolb, 1984).

14. In your role as first line supervisor, what type of capabilities have you developed in giving your employees opportunities to engage in key experiences? ______________________________

15. Any others? ______________________________

16. To what extent do you help your employees engage in key experiences when the situation required you to do so?
[Use a scale of 1 – 7, with 7 being “full extent” and 1 being “no extent”] ___________

17. OK. Let’s talk a bit more about the extent you helped your employee engage in key experiences…

Reflect for a moment on the activities in which you helped your employee engage in key experiences…

Describe an activity in which you helped your employee (directly or indirectly) engage in key experiences when the situation required you to do so. ___________

18. From a broad perspective, which activities were most helpful for your individual employee and why? ______________________________

19. What documents are you willing to share that support any of the activities you described above? ______________________________

Ask for copies of these documents.

Part 5: Collaborative Knowledge Construction.

Operational Definition of Collaborative Knowledge Construction:
Collaborative knowledge construction is a cognitive process that relates to the learners' cooperative learning. In the context of this study, learners collaborate to externalize knowledge in a consensus-building manner (Fischer et al., 2002).

20. In your role as first line supervisor, what type of capabilities have you developed in engaging your employees in a team that supports a collaborative knowledge construction process? ______________________________

21. Any others? ______________________________

22. To what extent do you help your employees engage in a team that supports a collaborative knowledge construction process, when the situation required you to do so?
[Use a scale of 1 – 7, with 7 being "full extent" and 1 being "no extent"] __________

23. OK. Let's talk a bit more about the extent you helped your employees engage in a team…

Reflect for a moment on the activities in which you helped your employees engage in a team that supports a collaborative knowledge construction process…

Describe an activity in which you helped your employees (directly or indirectly) engage in a team that supports a collaborative knowledge construction process when the situation required you to do so. ________________

24. From a broad perspective, which activities were most helpful for your employees and why? ____

25. What documents are you willing to share that support any of the activities you described above? ____

Ask for copies of these documents.

Part 6: Recap and New Ideas.

Let's see if we can put all of this together. We've talked about your employees' professional learning activities, mental models, key experiences, and collaborative knowledge construction processes.

26. On this piece of paper, (give the person a blank sheet of paper) would you take a few minutes to show how all of these features link together. Would you draw a "map" or a flow chart that shows how this process unfolds? _____________

27. Does it unfold in a linear 1-2-3 process? Or is the process circular? Or is the process dynamic and interactive? How would you represent the process? ____

Please "talk aloud" as you draw.

28. Are there relationships in this "map" that need to be clarified and how so? _____

29. Finished? OK, great. To make sure I understand the process, would you walk me through it? Please use a specific example if you can. _________________

30. Any more ideas you'd like to add about how you engage your employees in professional learning activities? _______________________________________

31. Any ideas we have not covered? _____________________________________

Part 7: Permission for Follow-up Interview.

You mentioned of certain documents in this interview that may help describe the nature of current professional learning practices in your organization. I'd like to get your permission to come back in a follow-up interview so that these documents can be shown and explained in more detail.

32. Would you participate in a 30-minute follow-up interview so that you can provide me copies of the documents you mentioned in Parts 3, 4, and 5 and explain how they relate to current professional learning practices in your plant? ____

Thank you again for your time. Your responses have been very helpful.

Appendix F

Consent Form for First-Line Worker Participation in a Research Study

Consent Form for Participation in a Research Study

University of Connecticut

Principal Investigator: Barry G. Sheckley, Ph.D.
Student Researcher: Parker A. Grant
Study Title: Professional Learning and Lean Manufacturing

Introduction

You are invited to participate in a research study to tell how you learn and solve problems. You are being asked to participate because you are a first line employee. Also because your first line supervisor gave me your name as a possible candidate for the interview.

Why is this study being done?

The purpose of this research study is to find out how your first line supervisor helps you learn and solve problems. The study will help managers make a better learning program for first line supervisors to use and follow.

What are the study procedures? What will I be asked to do?

There are four parts to the research study. The first part was the survey and the second part is the interview. The third part is a review of your interview responses. The fourth part is another interview to review your documents.

1. You completed a survey that asked for your name and experience. To be in the study, you needed to have at least 12 months of experience in your work cell. As a result of the screening [redacted] will be in the study.

2. You will be asked to take part in an interview. The interview will last about 90 minutes long. The interview will be in a private room either in your building or in the [redacted]. The researcher will ask for your permission to digitally record your voice in the interview. This will help us get your information correctly. If you do not feel comfortable at any time in the interview, you can stop the interview and the voice recording.

   The interview questions will ask about how your first line supervisor helps you:
   - solve problems
   - describe your ideas
   - get key experiences
   - create knowledge in a team

This interview will take place in [redacted]. During the interview the researcher will ask for copies of documents. These documents will relate back to some of your

interview responses. For example, the documents could be value stream maps, process maps, root cause diagrams, etc. You can give these documents to the researcher in the next interview (part 4).

1. About 2 weeks after the interview, you will be given a typed copy of your responses. At this time, you will have the chance to review your responses to be sure they are correct. Your review will take about 30 minutes. Then you can give the researcher all corrections in an email, phone call, or in person at your convenience.

2. About 1-2 weeks after the interview, the researcher will interview you in person again. This time the interview will be about 30 minutes long and will focus on your documents.
   a) The interview will be in a private room either in your building or in [redacted].
   b) The researcher will not digitally record your voice in the interview.
   c) If you do not feel comfortable at any time in this interview, you can stop the interview.
   d) Before you give copies of the documents to the researcher, you will need to black out all names on the copies. This way, the researcher will not know the names written on the documents. This will help protect the identity of the people whose names are on the documents.

What are the risks or inconveniences of the study?

We believe there are no risks to you for your participation in this research study. A possible inconvenience may be the time it takes for you to complete the study.

If you are not comfortable with any interview question, you can choose not to answer it.

What are the benefits of the study?

You are not expected to benefit from this research; however, we hope that your participation in the study may advance the knowledge of how adults learn in a production factory. The researcher will use the findings from this study in the context of his position at the company. The study will find out how first line supervisors help employees learn. The findings could help learning managers build a better employee learning program. As a result, this new learning program could help improve lean production.

Will I receive payment for participation? Are there costs to participate?

There are no costs to participate in this study.

After the study, you have the choice to enter a drawing to win a $100 gift. If you win, you will get an Amazon.com gift certificate. This will come to you in an email address you give.

However, you will not be allowed to enter the drawing if you do not finish the study.

If you want to enter the drawing, you will complete an information card. You can do this at your interview. The card will ask for your name and how you would like to be notified of your win (for example, email, phone call, or internal mail). On the card, you will also be asked to give your preferred email address to get the online gift certificate.

All of the participants who choose to enter the random drawing will have their cards placed in an empty box. The box will be shaken and the researcher will reach into the box and pick one card. The chosen card will be the winner of the gift certificate.

The drawing will take place by no later than [redacted]. Only the winner will be notified of the results.

How will my personal information be protected?

The procedures below will help make your data confidential.

1) The researchers will keep all study records locked in a secure location. This includes any codes to your data. The study records will be locked in the [redacted].
2) Research records will be labeled with a code. The code will be made from [redacted].
3) A master key that links names and codes will be locked in the [redacted]. The master key will be [redacted].
4) Your digital voice records from the interview will be typed up by a company that is hired by your company. The digitally recorded audio tapes themselves will not be shared with management or FLSs. The voice records will be [redacted].
5) All electronic files that identify you will be locked with a password. The files include databases and spreadsheets. Any computer that hosts these files will also be locked with a password. These files will be on the [redacted]. [redacted] have firewall and password protection. Only the members of the research staff will have access to the passwords. The data will be kept indefinitely. [redacted].
6) Data that will be shared with others will be coded with [redacted]. This method will help protect your identity.
7) At the conclusion of this study, the researchers may publish or present their findings. The findings will be in a summary form.
   a) The findings may be given to the management team in your company. However, your name will not be given to the management team. The findings will not expose you to the risk of being identified. The findings will help the management team decide on a new learning program for you and the company.
   b) The findings may be presented at a conference. However, your name will not be given at the conference. The findings will not expose you to the risk of being identified. The findings will help managers in the training industry improve their learning programs. Your company's publication release policies will be followed.
   c) The findings may be published in an article or a book in print or on the Internet. However, your name will not be given in the article or the book. The findings will not expose you to the risk of being identified. Also, your company's publication release policies will be followed.

a) The answers you give in the interview may be quoted. The quotes may be direct or indirect in the summary. The quotes may also be paraphrased in the summary. However, your quotes will not expose you to the risk of being identified. For example:
   i) If you mention of doing a particular task that no one else does, this task will be removed from the summary.
   ii) If you mention the name of your work cell, this name will be removed from the summary.

The student researcher is also an employee of your company. If you made a violation and tell about it in the interview, it may need to be reported. The situations below will NOT help make your data confidential.

- You violate your company's code of ethics and tell about it in the interview. In this case the student researcher may need to report it to your management.
- You violate your company's policies and tell about it in the interview. The student researcher may need to tell this to your management.
- You violate the law and tell about it in the interview. The student researcher may need to tell this to your management.

You should also know that the UConn Institutional Review Board (IRB) and the Office of Research Compliance may inspect study records as part of its auditing program, but these reviews will only focus on the researchers and not on your responses or involvement. The IRB is a group of people who review research studies to protect the rights and welfare of research participants.

Can I stop being in the study and what are my rights?

You do not have to be in this study if you do not want to. If you agree to be in the study, but later change your mind, you may drop out at any time. There are no penalties or consequences of any kind if you decide that you do not want to participate.

For the survey or for the interview, you do not have to answer any question that you do not want to answer.

At any time you may be withdrawn from the study if you miss more than one appointment. You may also be withdrawn if you do not follow the interview process or if you have adverse reactions.

Who do I contact if I have questions about the study?

Take as long as you like before you make a decision. We will be happy to answer any question you have about this study. If you have further questions about this project or if you have a research-related problem, you may contact the principal investigator, Dr. Barry Sheckley at [redacted] or the student researcher, Parker Grant at [redacted]. If you have any questions concerning your rights as a research subject, you may contact the University of Connecticut Institutional Review Board (IRB) at [redacted].

Documentation of Consent:

I have read this form and decided that I will participate in the project described above. Its general purposes, the particulars of involvement and possible hazards and inconveniences have been explained to my satisfaction. I understand that I can withdraw at any time. My signature also indicates that I have received a copy of this consent form.

______________________	______________________	___________
Participant Signature:	Print Name:	Date:
______________________	______________________	___________
Signature of Person Obtaining Consent	Print Name:	Date:

Appendix G

First-Line Worker Interview Protocol

Part 1. Introduction and Interviewee Signed Informed Consent.

Good afternoon/evening. My name is Parker Grant. Before we begin, I would like to thank you for taking the time to talk with me today.

I am working on a research project for my dissertation in the Adult Learning Program at the University of Connecticut. We are interested in knowing more about how adults learn in a lean manufacturing setting.

During the next 1.5 hours or so, I will ask you some questions about your own professional learning experiences. I'd also like your consent to tape-record your response so that I may review your words at a later time.

Let me emphasize one point: If you are uncomfortable with any aspect of the interview, please feel free to say so. We can stop the tape recorder or the interview at any time you wish. No explanations required.

Do you have any questions at this point? ____

If you are agreeable to proceeding with the interview, I would like to ask you for your signed consent at this time. Your signature on the consent form indicates that you have a general understanding of what your participation in this study involves and that you willingly consent to participate.

OK? Ready to begin? ____

Now that the tape-recorder is on, please state your name, the date, and that you consent to have your response tape-recorded. __________________________________
____

Part 2: Background Information.

Operational Definition of Professional Learning:

Professional Learning is *any* activity that contributes to learning within the learner's profession. Examples of professional learning activities include job assignments, formal training, informal training, team-based projects, etc.

1. To begin, would you tell me a bit about your prior work experience? __________
____
____

2. During the time you have reported to your current supervisor, what type of professional learning activities has your supervisor help you engage in those activities? ____
____
____

3. Any others? ____

4. To what extent does your supervisor engage you in professional learning activities?
[Use a scale of 1 – 7, with 7 being "fully engage" and 1 being "do not engage"] ____

5. OK. Let's talk a bit more about the extent your supervisor engages you in professional learning activities…

   Reflect for a moment on the professional learning activities in which you were engaged by your supervisor…

   Describe a professional learning activity in which your supervisor engaged you when the situation required you to do so. ______________________________
____
____
____

6. Think in broad terms of experiences, relationships, key activities, critical events, and the like. No need to confine yourself to classroom-type events. From this broad perspective, what professional learning activities were most helpful for you and why? ____________________________________
____
____

Part 3: Mental Models.

Operational Definition of Mental Model:

A learner's mental model represents his/her view of how the world works. It influences how the learner understands the world and how he/she takes action (Senge, 1990). In the context of this study, learners use their mental models to guide their work.

Example of Mental Model from:
http://www.boxesandarrows.com/view/whats_your_idea_of_a_mental_model_

"If I tell them that I recently ordered a steak at a restaurant, they might assume that I was met at the door by a host or hostess, seated, and presented with a menu. They assume these details, and others, that I never actually mentioned because they have a mental model of how restaurants operate. To illustrate the consequences of having a mismatched mental model, I describe a person who goes into a buffet restaurant and waits for someone to take their order. The person's mental model of how that restaurant operates doesn't match the actual situation, and he would experience confusion and frustration until he modified his original model to include buffets."

7. In your role as employee, in what ways does your supervisor understand your mental model that guides your work? ________________________________
____
____

8. Any others? ____

9. To what extent does your supervisor help bring your mental model to the surface when the situation required you to do so?
[Use a scale of 1 – 7, with 7 being "full extent" and 1 being "no extent"] ________

10. OK. Let's talk a bit more about the extent your supervisor brought your mental model to the surface…

    Reflect for a moment on your supervisor's activities that helped surface your mental model…

    Describe an activity in which your supervisor helped you (directly or indirectly) surface your mental model when the situation required you to do so. ____
____
____
____

11. From a broad perspective, which activities were most helpful for you and why? ____
____

12. In what ways does your supervisor help you to build upon your current mental model that guides your work? ______________________________
____

13. What documents are you willing to share that support any of the activities you described above? ______________________________

Ask for copies of these documents.

Part 4: Key Experiences.

Operational Definition of Key Experience:

Key experiences for learners are rich, multi-faceted, and wide ranging (Sheckley, 2007). In the context of this study, learners learn from transforming experiences into knowledge (Kolb, 1984).

14. In your role as employee, in what ways does your supervisor give you opportunities to engage in key experiences? ______________________________
____
____

15. Any others? ______________________________

16. To what extent does your supervisor engage you in key experiences when the situation required you to do so?
[Use a scale of 1 – 7, with 7 being “full extent” and 1 being “no extent”] ________

17. OK. Let’s talk a bit more about the extent your supervisor helped you engage in key experiences…

    Reflect for a moment on your supervisor’s activities in which you were engaged in key experiences…

    Describe an activity in which your supervisor engaged you (directly or indirectly) in key experiences when the situation required you to do so. ________
____
____
____

18. From a broad perspective, which activities were most helpful for you and why? ______________________________
____

19. What documents are you willing to share that support any of the activities you described above? ____

Ask for copies of these documents.

Part 5: Collaborative Knowledge Construction.

Operational Definition of Collaborative Knowledge Construction:
Collaborative knowledge construction is a cognitive process that relates to the learners' cooperative learning. In the context of this study, learners collaborate to externalize knowledge in a consensus-building manner (Fischer et al., 2002).

20. In your role as employee, in what ways does your supervisor engage you in a team that supports a collaborative knowledge construction process? ______
____
____

21. Any others? ____

22. To what extent does your supervisor engage you in a team that supports a collaborative knowledge construction process, when the situation required you to do so?
[Use a scale of 1 – 7, with 7 being "full extent" and 1 being "no extent"] _______

23. OK. Let's talk a bit more about the extent your supervisor helped engage you in a team…

    Reflect for a moment on your supervisor's activities in which you were engaged in a team that supports a collaborative knowledge construction process…

    Describe an activity in which your supervisor engaged you (directly or indirectly) in a team that supports a collaborative knowledge construction process when the situation required you to do so. _________________________
____
____
____

24. From a broad perspective, which activities were most helpful for you and why? ____
____

25. What documents are you willing to share that support any of the activities you described above? ____

Ask for copies of these documents.

Part 6: Recap and New Ideas.

Let's see if we can put all of this together. We've talked about your professional learning activities, mental models, key experiences, and collaborative knowledge construction processes.

26. On this piece of paper, (give the person a blank sheet of paper) would you take a few minutes to show how all of these features link together. Would you draw a "map" or a flow chart that shows how this process unfolds? ________

27. Does it unfold in a linear 1-2-3 process? Or is the process circular? Or is the process dynamic and interactive? How would you represent the process? ____
____

Please "talk aloud" as you draw.

28. Are there relationships in this "map" that need to be clarified and how so? ______
____

29. Finished? OK, great. To make sure I understand the process, would you walk me through it? Please use a specific example if you can. _______________
____

30. Any more ideas you'd like to add about how you were engaged in professional learning activities? ____
____
____

31. Any ideas we have not covered? ____
____

Part 7: Permission for Follow-up Interview.

You mentioned of certain documents in this interview that may help describe the nature of current professional learning practices in your organization. I'd like to get your permission to come back in a follow-up interview so that these documents can be shown and explained in more detail.

32. Would you participate in a 30-minute follow-up interview so that you can provide me copies of the documents you mentioned in Parts 3, 4, and 5 and explain how they relate to current professional learning practices in your plant? ____

Thank you again for your time. Your responses have been very helpful.

Appendix H

Research Participant Drawing for Gift Certificate

Research Participant Drawing for $100.00 Amazon Gift Certificate

Research Study Participant Name ___________________________________

☐ Yes, I would like to participate in this drawing.
☐ No, I would not like to participate in this drawing.

How would you like to be notified if you win this drawing?
☐ Email
☐ Phone
☐ Inter-office mail

Participant Signature: ____