Critical Success Factors for Sustaining Kaizen Event Outcomes

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ABSTRACT

A Kaizen event is a focused and structured improvement project, using a dedicated cross-functional team to improve a targeted work area, with specific goals, in an accelerated timeframe. Kaizen events have been widely reported to produce positive change in business results and human resource outcomes. However, it can be difficult for many organizations to sustain or improve upon the results of a Kaizen event after it concludes. Furthermore, the sustainability of Kaizen event outcomes has received limited research attention to date.

This research is based on a field study of 65 events across eight manufacturing organizations that used survey data collected at the time of the event and approximately nine to eighteen months after the event. The research model was developed from Kaizen event practitioner resources, Kaizen event literature, and related process improvement sustainability and organizational change literature. The model hypothesized that Kaizen Event Characteristics, Work Area Characteristics, and Post-Event Characteristics were related to Kaizen event Sustainability Outcomes. Furthermore, the model hypothesized that Post-Event Characteristics would mediate the relationship between Kaizen Event and Work Area Characteristics and the Sustainability Outcomes. The study hypotheses were analyzed through multiple regression models and generalized estimating equations were used to account for potential nesting effects (events within organizations).

The factors that were most strongly related to each Sustainability Outcome were identified. Work Area Characteristics *learning and stewardship* and *experimentation and continuous improvement* and Post-Event Characteristics *performance review* and *accepting changes* were significant direct or indirect predictors of multiple Sustainability Outcomes and these findings were generally supported by the literature. There were also some unanticipated findings, particularly regarding the modeling of Sustainability Outcomes *result sustainability* and *goal sustainability,* which appear to illustrate potential issues regarding how organizations define and track the performance of Kaizen events over time and present areas for future research. Overall, this study advances academic knowledge regarding Kaizen event outcome sustainability. The findings also present guidelines so that practitioners may better influence the longer-term impact of Kaizen events on their organizations. The research findings may also extend to other improvement activities, thus presenting additional areas for future work.

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CHAPTER 1: INTRODUCTION

1.1 Research Motivation

A Kaizen event is "a focused and structured improvement project, using a dedicated cross-functional team to improve a targeted work area, with specific goals, in an accelerated timeframe" (Farris et al., 2008, p.1). Often used in conjunction with an organization's lean manufacturing or lean production efforts (Alukal, 2006; Manos, 2007; Ting, 2004), the concept of Kaizen events began appearing in the 1970s (Montabon, 2005; Sheridan, 1997). Toyota is recognized as the first organization to implement this form of improvement mechanism (Bicheno, 2001; Sheridan, 1997). Many companies observing Toyota's successful use of Kaizen events seem to have been inspired to implement this improvement approach.

Practitioners report a variety of business-related, or technical system, improvements after a Kaizen event, including improvements to *lead-time, floor space, WIP, setup time/loading time, market share/throughput, walk time/parts travel time, defect rate/quality issues,* and *on-time delivery/customer wait time* (e.g., Vasilash, 1993; Cuscela, 1998; Melnyk et al., 1998; Minton, 1998; McNichols et al., 1999; Bane, 2002; Bradley and Willett, 2004). In fact, some report significant technical system improvements, for example 120%-400% increases in *productivity* (Cuscela, 1998). Practitioners also report significant human resource, or social system, improvements after a Kaizen event. For example, one organization reported 120 to 175 new *ideas generated* during a Kaizen event (Cuscela, 1998). Other commonly-cited social system improvements reported in the Kaizen event practitioner literature include *labor turnover, employee empowerment,* and *employee satisfaction* (e.g., Melnyk et al., 1998; Minton, 1998; McNichols et al., 1999; Hasek, 2000; Smith, 2003).

However, a major obstacle for many organizations is to sustain the improvements from a Kaizen event over time (Bateman, 2005; Friedli, 1999; Mackle, 2000). In fact, Laraia et al. (1999) report that many organizations find great difficulty in sustaining over time even 50% of the improvements initially realized at the conclusion of the event. Empirical research of Kaizen events suggests that the rate of sustainability may be even lower. In one recent study, three of the eleven (27%) Kaizen events studied were unable to sustain any of the changes that were implemented during the Kaizen event (Burch, 2008). The inability to sustain Kaizen event outcomes may have significant consequences for the progress of a work area, may impact

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neighboring work areas, and may impede the use of this improvement mechanism in the future (Bateman and Rich, 2003).

Some practitioners note that Kaizen events should not be performed unless they are done with the intent and activities necessary to sustain results (e.g., Mackle, 2000). To date, however, there has been limited empirical research in this area and additional research would enrich the body of Kaizen event sustainability knowledge in a variety of ways. For instance, many are case studies of a single organization (e.g., Patil, 2003; Magdum and Whitman, 2007) and thus their findings are limited in terms of their generalizability. A recent study of Kaizen event sustainability (Burch, 2008) considered multiple organizations, but studied a relatively smaller number of Kaizen events (n=13) and the research model did not include characteristics of the Kaizen event or the use of any post-event mechanisms. The most extensive multiple-site research initiative of Kaizen events to date did not differentiate between Kaizen event initial vs. longer-term outcomes (Bateman and David, 2002; Bateman, 2005). This research aims to address these concerns and opportunities for additional research.

While organizational, process and continuous improvement sustainability research studies have reached some conclusions about how to achieve long-term sustainability, most of these studies do not specifically address Kaizen events (Dale et al., 1997; Kaye and Anderson, 1999; Oxtoby et al., 2002; Upton, 1996; Keating et al., 1999; Goodman and Dean, 1982). The study of Kaizen event sustainability as a unique research stream (apart from the general continuous improvement research) is justified in part because the key differences between Kaizen events and general continuous improvement mechanisms may imply differences in factors related to results sustainability. For example, the short-term nature that is inherent to Kaizen events may create the immediate benefits that have been found to increase employee commitment to a continuous improvement program over time (Keating et al., 1999; Kotter, 1995). Conversely, the immediate benefits attained through Kaizen events may be difficult to sustain, particularly when Kaizen events are used in an ad-hoc manner, because, given the short-term "focus," they may be less likely to be used in conjunction with long-term activities (Radnor and Walley, 2009) that are a part of the success of continuous improvement programs (Kaye and Anderson, 1999).

Justification of the study of Kaizen event sustainability, especially with the use of quantitative data, is further supported by the fact that most of the continuous improvement

literature tends to focus on the larger improvement program and generally draws from case study material (Bateman, 2005). The present research focuses on the outcomes of individual improvement projects (i.e., Kaizen events) using data from multiple events across several organizations.

The problems of varied initial Kaizen event outcomes and the sustainability of outcomes are the motivation for a NSF-funded research initiative to understand critical factors that influence Kaizen event outcomes. This research was conducted between Oregon State University and Virginia Tech (OSU-VT). In the first phase of this multi-year research grant, researchers identified the critical factors related to initial Kaizen event success and provided practitioners with insight on improving initial success (Farris, 2006; Farris et al., 2009). The findings from the first phase of the OSU-VT research initiative also provides the foundation for the current research, the second phase of this research initiative, to determine the factors related to sustained Kaizen event outcomes.

1.2 Research Purpose and Objectives

The purpose of this research is to determine the factors most related to Kaizen event outcome sustainability. The types of factors that are explored are:

- Work Area Characteristics: factors that are related to the work area's group learning behaviors, group stewardship, and knowledge of continuous improvement as defined by Groesbeck (2001) and Doolen et al. (2003), as well as work area routineness (Farris, 2006) and the changes that may have occurred in the work area since the Kaizen event (e.g., changes to the work area management).
- Kaizen Event Characteristics: factors that are related to the initial Kaizen event as defined by Farris (2006).
- Post-Event Characteristics: activities conducted after the conclusion of a Kaizen event in order to fully integrate, monitor, and support the changes in the targeted work area.

To fulfill this purpose, the following research objectives were identified:

- *Conduct a systematic Kaizen event literature review.* A systematic review was conducted in order to thoroughly assess the current state of the Kaizen event literature. Systematic reviews provide a rigorous, relevant basis for pursuing new research areas by assessing

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current research outcomes (Brereton et al., 2007). A systematic review of the Kaizen event body of knowledge is of particular interest to the present research because of the current lack of Kaizen event sustainability research. The review provided a methodical approach to compile information from not only the existing academic literature but also from the larger number of practitioner resources to reasonably assure that all sources of information were examined; converging and diverging practices as well as topics that have not been previously explored in the current body of knowledge were used to inform the present research. Special emphasis was placed on the current Kaizen event literature that related to the sustainability of outcomes. This systematic literature review was used to provide support for the inclusion of the measures used in this study, as elaborated on in the following objective.

- *Operationally define the Work Area Characteristics and Post-Event Characteristics that are believed to be related to Kaizen event outcome sustainability.* The potentially critical work area factors and post-event factors were identified from the related literature and observation of participating research partner organizations. These factors were formally defined through a review of organizational, continuous improvement, and process improvement sustainability literature (e.g., Bateman, 2005). These factors were then operationalized as survey scales and objective measures.

- *Analyze and identify the critical factors influencing sustainability of Kaizen event outcomes.* The term "T0 data" was used in this research to refer to data that were collected at the beginning and immediately after a Kaizen event. The term "T1 data" was used in this research to refer to data that were collected approximately nine to eighteen months after a Kaizen event. Analysis included the T0 and T1 data gathered for all events studied across multiple manufacturing organizations. This research defined and empirically tested a research model that accounted for both the event T0 and T1 factors that impact event social and technical system outcome sustainability.

1.3 Research Model and Definitions

Figure 1 illustrates the preliminary theory-based research model that describes the proposed factors hypothesized to be related to Kaizen event outcome sustainability. Additional details regarding the research model are presented in Section 2.7. The model was based on the

organizational institutionalization of change model originally developed by Goodman and Dean (1982). The general premise of the institutionalization model is that organizational characteristics and the structure of the change impact institutionalization processes, which in turn impact the institutionalization criteria. The institutionalization theory as well as the structure of the institutionalization model translates well to the working theory of Kaizen event outcome sustainability. Furthermore, because Kaizen events are reported to have technical and social system benefits, sociotechnical systems (STS) theory was also used to support the research model (Trist and Bamforth, 1951; Emery and Trist, 1960; Pasmore and King, 1978; Miner, 2006). Sociotechnical systems theory emphasizes joint optimization between the task or technical environment and the social system within a given organization (Miner, 2006). STS theory informed the selection of the Sustainability Outcomes as well as the other model variables. For example, social system-related Work Area Characteristics, e.g., the group learning behaviors of the work area, as well as technical system-related Work Area Characteristics, e.g., changes in the product mix of the work area since the Kaizen event, were considered in the research model.

In the preliminary model of Kaizen event outcome sustainability, Work Area Characteristics, Kaizen Event Characteristics, and Post-Event Characteristics impact the sustainability of outcomes. The Post-Event Characteristics may also mediate the relationship between the sustainability of Kaizen event outcomes and the Work Area Characteristics and Kaizen Event Characteristics. The following provides additional detail regarding the Work Area Characteristics, Kaizen Event Characteristics, Post-Event Characteristics, and Sustainability Outcomes that were included in the preliminary research model.
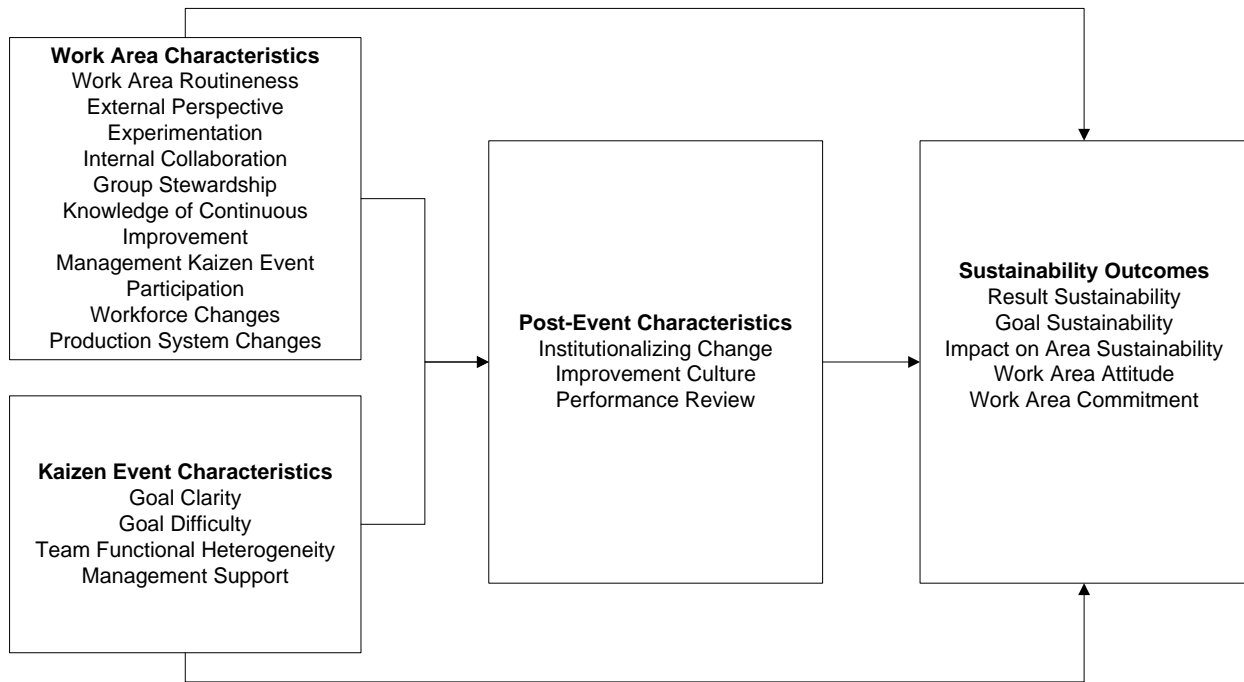
Figure 1. Preliminary Operational Research Model

Fourteen variables were included in the study of Kaizen event initial effectiveness (Farris, 2006). This preliminary model includes four of these variables as Kaizen Event Characteristics that may impact the sustainability of Kaizen event outcomes. One of these variables, *work area routineness*, is included as a Work Area Characteristic. These variables were chosen based on support from the current sustainability literature. The Kaizen Event Characteristics are:

- *Goal clarity:* describes team member perceptions of the extent to which the Kaizen event team's improvement goals have been clearly defined.

- *Goal difficulty*: describes team member perceptions of the difficulty of the improvement goals set for the Kaizen event team.

- *Team functional heterogeneity:* describes the diversity of functional expertise within the Kaizen event team.

- *Management support:* describes the support that senior leadership provided to the team, including materials and supplies, equipment and assistance from organizational members, e.g., the facilitator, senior management and others.

The Work Area Characteristics studied in this research are:

- *Work area routineness:* describes the general complexity of the target system, based on the level of stability of the product mix and degree of routineness of product flow (Farris, 2006).

- *External perspective:* describes the degree to which work area employees relate their work to the larger organization (Groesbeck, 2001).

- *Experimentation:* describes the degree to which work area employees try new things through application to aid in learning (Groesbeck, 2001).

- *Internal collaboration:* describes the degree to which work area employees ask and answer questions of one another (Groesbeck, 2001).

- *Group stewardship:* describes the degree to which work area employees act in the best interest of the organization (Groesbeck, 2001).

- *Knowledge of continuous improvement:* describes the degree to which work area employees have knowledge of the continuous improvement philosophy (Doolen et al., 2003).

- *Management Kaizen event participation:* describes whether current management has participated in at least one Kaizen event and whether current management had participated in at least one Kaizen event at the time of the observed Kaizen event.

- *Workforce changes:* describes whether the work area has experienced management turnover and the percentage of current work area employees that were also working in the work area at the time of the Kaizen event.

- *Production system changes:* describes whether there have been work area equipment changes, product volume changes, and/or product mix changes in the work area since the Kaizen event.

The Post-Event Characteristics studied in this research are:

- *Institutionalizing change:* activities conducted to finish implementing changes identified through the Kaizen event and to incorporate changes into the ongoing, everyday activities of the target system.

- *Improvement culture*: encouragement of organizational improvement through management's support of the use of Kaizen events and continuous improvement activities among work area employees and Kaizen event team members.

- *Performance review*: describes the extent to which the organization measures and evaluates the results of the Kaizen event.

The technical system Sustainability Outcomes studied in this research are:

- *Result sustainability*: the aggregate percentage of improvement results sustained related to the primary goals of the event, or T1 performance compared with T0 performance.

- *Goal sustainability*: the aggregate percentage of the primary improvement goals of the event compared to T1 performance.

- *Impact on area sustainability*: describes team member perceptions (at T0) and the perceptions of the facilitator/work area manager (at T1) of the sustained impact of the Kaizen event on the work area.

The social system Sustainability Outcomes studied in this research are:

- *Work area attitude*: describes the perceptions at T1 of the facilitator/work area manager about the degree to which work area employees' liking for Kaizen event activities increased as a result of the event.

- *Work area commitment:* describes the perceptions of the facilitator/work area manager of the degree to which work area employees and management believe in the need for and value of the specific changes targeted by the Kaizen event at T1.

1.4 Research Hypotheses

The preliminary research hypotheses describe the relationships that were tested in this research:

- H1. Kaizen Event Characteristics are positively related to Sustainability Outcomes at the team level.

- H2. Work Area Characteristics are positively related to Sustainability Outcomes at the team level.

- H3. Post-Event Characteristics are positively related to Sustainability Outcomes at the team level.

- H4. Post-Event Characteristics partially mediate the relationship of Kaizen Event Characteristics and Sustainability Outcomes.

- H5. Post-Event Characteristics partially mediate the relationship of Work Area Characteristics and Sustainability Outcomes.

These hypotheses are statistically tested using multiple regression techniques presented in Chapter 4.

1.5 Overview of Research Design, Premises, and Delimitations

The research design is an observational field study that sampled Kaizen events across multiple manufacturing organizations in order to test the working theory of Kaizen event outcome sustainability. The study can also be characterized as survey research because it examines a phenomenon, Kaizen events, in a wide variety of natural settings (e.g., multiple companies) and does not involve treatment manipulation (instead, using questionnaires to survey the targeted population) (Davis and Cosenza, 1985; King and He, 2005). The use of survey design is a prominent approach to research, especially in the study of organizations (Mitchell, 1985). In fact, the key premise of the present research design and, in general, the OSU-VT research design (e.g., Farris, 2006) is that conducting field studies of Kaizen events as opposed to experimentation is preferred because it improves the potential generalizability of the study (Cohen and Bailey, 1997).

This research has limitations that are similar to those identified in the first phase of the OSU-VT research (Farris, 2006), including:

- This research did not attempt to study all potential Sustainability Outcomes. The related literature, including Kaizen event literature and continuous improvement literature, was reviewed to identify the succinct set of Sustainability Outcomes that appeared to be most aligned with previous studies of Kaizen event outcome sustainability (e.g., Bateman, 2005; Patil, 2003) and were especially relevant to the advancement of the Kaizen event body of knowledge. Future research could consider additional outcome measures.

- This research did not attempt to study all Kaizen Event Characteristics, Work Area Characteristics, or Post-Event Characteristics that may impact Kaizen event outcome sustainability. Kaizen event sustainability literature and related literature were used to identify the characteristics that have been indicated by previous studies as factors that may be critical to the sustainability of Kaizen event outcomes. A separate set of variables that were

not as strongly supported in the literature or were similar to the variables that were included in the preliminary research model were considered in post-hoc analysis. Based on the findings of the present research, additional variables that could be considered for future research are suggested (Chapter 6).

- This research's sample size was limited in terms of the number, type, and location of participating organizations, which may impact generalizability. Sixty-five Kaizen events were sampled across eight organizations. All participating organizations were manufacturing organizations, so it is possible that the findings may be affected by industry type and cannot be generalized to other industries. However, at the event level, the sampled events had a variety of goals, processes, targeted work areas, etc., thus increasing the support for the generalizability of the research findings. Finally, in the first phase of the research, site visits were conducted to train organizational personnel in the data collection methods and to better understand the context of the data collected. In order to conduct these site visits while controlling costs, the organizations were limited geographically to within a day's drive of either VT or OSU (Farris, 2006). Further research could consider a larger sample size of events with a larger number of participating organizations across a broader range of locations.

Because the present research considers the sustainability of Kaizen event outcomes, there are additional limitations to the research design, including:

- T1 survey data e.g., Work Area Characteristics and Sustainability Outcomes) were collected from facilitators or work area management as opposed to collecting the data from the workforce. In other words, T1 data was only collected from the facilitators or work area management; thus, one respondent provided perceptions about the overall work area (as opposed to multiple respondents). This collection method limits the accuracy of the measurements. While the OSU-VT research team originally attempted to collect T1 data from the targeted work area employees, they experienced difficulty administrating the questionnaires for the first few events due to various reasons (e.g., limited time to administer the questionnaire by the facilitators and to complete questionnaires by work area employees, given their respective work responsibilities). It is possible that the responses from the workforce regarding their perceptions would be different than the responses given by the facilitator or work area manager. Furthermore, because either the work area manager or the

Kaizen event facilitator was surveyed at T1, their responses regarding the work area may be varied based on their understanding for the collective behavior and actions of the work area. For example, a Kaizen event facilitator who does not spend a great deal of time in a targeted work area may have difficulty assessing the group behaviors among work area employees. While data regarding the perceptions of the workforce throughout the research would have been beneficial, the present research's approach of using a facilitator or manager to assress the perceptions of the workforce is supported as it has been used in previous studies. For example, in a review of team literature, Cohen and Bailey (1997) found that questionnaires that focused on perceptions of overall team performance of parallel teams and work teams used responses from one or more managers nearly as often as from one or more team members.

- In this study, data were collected at T0 (i.e., at the beginning and within two weeks of the Kaizen event) and at T1 (i.e., approximately nine to eighteen months after the Kaizen event). A more precise time lapse between T0 and T1 (e.g., collecting all T1 data at exactly twelve months after the Kaizen event) could have strengthened the internal validity of the study (Davis and Cosenza, 1985). In addition, future study of Kaizen events using a longitudinal research design that considers the collection of data at additional points in time would be beneficial.

1.6 Contributions of this Research

This research contributes to the body of Kaizen event knowledge and practice in a number of ways. First, this research provides a systematic review of the Kaizen event body of knowledge. As the use of Kaizen events has increased, the number of academic and practitioner-focused publications discussing this process improvement phenomenon has also grown. It is important to periodically assess the past and present works in a field (Gattoufi et al., 2004). Such an assessment also allows the maturity of a field to be recognized. There have been previous reviews of Kaizen event literature (e.g., Kosandal and Farris, 2004). However, to the author's knowledge, a systematic assessment of the Kaizen event literature did not exist prior to the present research. By examining current Kaizen event publications and providing an assessment of each publication using an adaptation of the classification framework defined by Nissen (1996) the present research is able to assess the field's current maturity. The present research is also able

to present suggestions to address gaps in the Kaizen event research stream to support its advancement.

Second, this empirical research contributes to the body of Kaizen event knowledge by identifying the Kaizen Event Characteristics, Work Area Characteristics, and Post-Event Characteristics that are most strongly related to the sustainability of Kaizen event outcomes. The study results can be used to inform the theory of Kaizen events. Through the identification of the critical factors that influence Kaizen event outcome sustainability, the present research design, model, and analyses make the following unique contributions to the Kaizen event body of knowledge:

- The present research uses the largest sample size at the Kaizen event level to date (n=65), including both studies of Kaizen event initial outcomes and Kaizen event outcome sustainability. To the author's knowledge, the largest Kaizen event sample size in a study of Kaizen event outcome sustainability before the present research was n=40 (Bateman, 2005). By studying a larger sample size at the Kaizen event level, the research is able to conduct hypothesis testing with greater model robustness than previous studies.

- This research identifies and operationalizes new proposed Post-Event Characteristic survey scales. These scales can be used to inform future research of Kaizen events and may be useful in the study of other process improvement approaches.

- The present research empirically tests the working theory for studying and managing Kaizen event outcome sustainability through testing causal hypothesis testing via multiple regression techniques. To the author's knowledge, this is the first study to test causal relationships between Sustainability Outcomes and potentially critical factors of Kaizen event outcome sustainability.

Third, this research makes contributions to improvement and change research. This research contributes to the body of organizational change research because it empirically tests a model that was adapted from a generally accepted model in the organizational change literature, but has been minimally tested (Cummings and Worley, 1997). Also, the research findings may extend to the sustainability of other improvement activities, thus presenting additional areas for future research. Particularly, the present research sampled organizations that used Kaizen events programmatically, which is similar to the ongoing nature of the change mechanisms presented in the improvement and organizational change literature although it was not clear prior to the

research the extent to which the organizations focused on long-term support activities versus immediate results.

Fourth, this research contributes to organizational practice by providing Kaizen event practitioners (e.g., Kaizen event facilitators team leaders, and targeted work area management) additional information to understand the factors they may influence to sustain outcomes of interest. Specifically, management guidelines based on the research findings are presented. Such understanding will increase the likelihood that results of a given Kaizen event are sustained, eliminating wasted efforts and supporting further organizational improvement.

Lastly, the present research makes contributions to the field of industrial engineering and the disciplines of engineering management and operations management. Industrial engineering is defined as follows:

"Industrial engineering is concerned with the design, improvement and installation of integrated systems of people, materials, information, equipment and energy. It draws upon specialized knowledge and skill in the mathematical, physical, and social sciences together with the principles and methods of engineering analysis and design, to specify, predict, and evaluate the results to be obtained from such systems" (Institute of Industrial Engineers, 2010).

Likewise, the present research is concerned with the improvement of integrated systems of people, materials, information, equipment and energy; these systems are integral to the modeling of the present research. Also, specialized knowledge and skill in the mathematical, physical, and social sciences informed all stages of the research, including the research design, methods, and analyses. Through the utilization of perspectives and methods that are inherent to industrial engineering, this research contributes to the field by defining, analyzing, and interpreting the sustainability of Kaizen event outcomes; this impacts several levels of integrated work systems, i.e., the Kaizen event, the targeted work system, and the greater organization.

In addition to industrial engineering community, the present research also contributes to the engineering management (EM) and operations management (OM) communities. For example, the OM community has called for empirical research, including field survey studies (e.g., Meredith, 1998) in order to "reduce the gap between management theory and practice, to increase the usefulness of OM research to practitioners, and, more recently, to increase the scientific recognition of the OM field" (Forza, 2002, p. 152). Also, researchers suggest that the quality and appropriateness of survey research in OM-related areas should continue to be

improved (Forza, 2002). The present field survey research, using rigorous research design, modeling, and statistical analysis methods, contributes to both of these appeals. In addition, Kaizen events have often been used to make improvements in engineering-related processes (e.g., Wickiser, 2007; Goldacker, 2005). Further, engineering managers may sponsor, lead, participate in, or supervise employees who participate in Kaizen events (Farris et al., 2008). Therefore, the present research provides the EM community with guidelines to inform these practices. Also, various improvement phenomena have been the focus of the EM and OM disciplines (e.g., Adams et al., 1997; Bateman, 2005; Anand et al., 2009); the present research makes a unique contribution to the disciplines by advancing the knowledge of an improvement approach, i.e., Kaizen events and the sustainability of Kaizen event outcomes, that is not well understood in the industrial engineering, EM, or OM communities.

The remainder of this document is organized as follows. Chapter 2 provides a systematic review of the Kaizen event practitioner resources and academic literature and also presents the key process improvement, continuous improvement, and organizational change literature used to develop the initial research model and to develop the working theory of Kaizen event outcome sustainability. Chapter 3 describes the methods used to collect study data and to prepare the data for hypothesis testing. Chapter 4 presents the analysis methods used to test the study hypotheses and the results of the analyses. Chapter 5 provides discussion and interpretation of the research results. Chapter 6 presents the collective findings of this research, highlighting the variables that were significant across outcome variables.

CHAPTER 2: LITERATURE REVIEW

2.1 The Systematic Literature Review Method

This research follows the systematic review process for management research illustrated in Figure 2 (adapted from Tranfield et al., 2003). A systematic literature review differs from a traditional literature review because it defines and uses a detailed, formal protocol to identify the studies to review and also uses a set of *a priori* criteria to assess the quality of the set of selected studies, both of which may not be included in a traditional literature review. A full systematic review typically includes a researcher identifying studies to include in the review and extracting and synthesizing data from the selected studies for further analysis. This research uses *Phases 0-5* of the systematic review process in order to present a compelling motivation for the review of Kaizen event research and to conduct a systematic literature review. Chapter 1 addressed *Phases 0-1*. As presented in the Introduction, the lack of empirical research on Kaizen events and Kaizen event outcome sustainability presents the need for further review of the research area.

Phases 2-5 of the systematic review process are used in this section to conduct a systematic literature review by building upon a Kaizen event literature review conducted in earlier stages of the broader OSU-VT Kaizen event research initiative (Farris, 2006) and to support the inclusion of additional measures in the research of Kaizen event outcome sustainability. *Phases 6-9* could be used in future research to present a meta-analysis of the publications found in the review process but are outside of the scope of the present research.

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│ Systematic Review Phases Used in the Present Research            │
│ Phase 0 - Identification for the need for a review               │
│ Phase 1 - Preparation of a proposal for a review                 │
│ Phase 2 - Development of a review protocol                       │
│ Phase 3 - Identification of research                             │
│ Phase 4 - Selection of studies                                   │
│ Phase 5 - Study quality assessment                               │
│                                                                  │
│ Additional Systematic Review Phases                              │
│ Phase 6 - Data extraction and monitoring progress                │
│ Phase 7 - Data synthesis                                         │
│ Phase 8 - The report and recommendations                         │
│ Phase 9 - Getting evidence into practice                         │
└────────────────────────────────────────────────────────────────┘
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Figure 2. Systematic Review Phases (adapted from Tranfield et al., 2003)

2.1.1 Phase 2: Development of the Review Protocol

Table 1 includes the review protocol used to identify and select the studies for the Kaizen event sustainability review. Because Kaizen event sustainability literature is limited, this systematic review also included studies that examine sustainability with respect to process and continuous improvement methods. These additional areas were included in the search because a Kaizen event is a process improvement method (Alukal, 2006) and the sustainability of Kaizen event outcomes is often linked to other continuous improvement approaches, specifically lean (Bateman, 2005).

Table 1. Systematic Literature Review Protocol

Purposes of this Systematic Literature Review	• To systematically expand an existing literature review of Kaizen events (Farris et al., 2008), thus contributing to the understanding of the current Kaizen event body of knowledge. • To identify and review additional sources to inform the study of Kaizen event sustainability.
Search Strategy	• Search the identified databases by specific keywords. • Search the sources of fundamental papers (e.g., Bateman, 2005) found during the initial search.
Exclusion Criteria	Kaizen Event Search • A study will be excluded from the systematic review of Kaizen events if the majority of the study does not address Kaizen events. • Remove any duplicates and citations previously found by research team and listed in Farris, 2006.

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	Sustainability Search • A study will be excluded from the systematic review if the study does not discuss the outcome sustainability of a process or continuous improvement approach. • Remove any duplicates.
Keywords	Kaizen Event Search *Kaizen event* all fields *Kaizen blitz* all fields *Rapid improvement workshop* all fields *Accelerated improvement workshop* all fields Sustainability Search *Process Improvement* AND *Sustainability* all fields excluding full text *Continuous Improvement* AND *Sustainability* all fields excluding full text
Databases	Engineering Village Emerald ISI ProQuest JSTOR IEEE Transactions on Engineering Management

2.1.2 Phases 3-4: Identification of Research and Selection of Included Studies

In *Phase 3-Identification of Research*, 576 Kaizen event publications and 841 sustainability publications were identified using the keyword searches in each selected database. The high number of Kaizen event publications was due to the 473 Kaizen event publications found in the ProQuest database with the *Kaizen event* and *Kaizen blitz* keyword searches included in the full text. These ProQuest database results included a large number of newspaper and trade magazine articles that sparsely mentioned Kaizen events. Therefore, the ProQuest database keyword searches for *Kaizen event* and *Kaizen blitz* were adjusted from full text searches to searching the bibliographic citation and abstract.

The results of the Sustainability publication search varied greatly and many were related to environmental sustainability. Thus the keyword search, *institutionalizing change* in all fields excluding full text, was added to the review protocol to more accurately sequester relevant publications. After these adjustments, 138 publications were identified as input for *Phase 4*. In *Phase 4-Selection of Included Studies*, the author used the review protocol's exclusion criteria,

which includes the exclusion of duplicate entries, to select 80 new Kaizen event-specific studies based on the search results from the keywords "kaizen event", "kaizen blitz", "rapid improvement workshop", and "accelerated improvement workshop" for inclusion in the final literature review. Eighteen sustainability-specific (non-Kaizen event) studies based on the search results from the keywords process improvement AND sustainability," "continuous improvement AND sustainability," and *"institutionalizing change"* were selected for inclusion in the final literature review.

2.1.3 Phase 5: Quality Assessment of Included Kaizen Event Studies
A quality assessment of a literarature stream can be done many ways. For example, Neely (2005) explores the evolution of performance measurement research through a citation/co-citation analysis method. Using bibliometric software called Sitkis, the frequency with which the top 5% of performance measurement researchers and their individual publications were cited, the types of journals in which the publications appeared, and the frequency of their citations over time were extracted. Neely also used social network analysis software, CINET, to determine how often these top researchers were co-cited and how often pairs of keywords were included across the most frequently cited works. The evolution of performance measurement research with respect to the types of articles that are being published (e.g., methods of application and theoretical verification or empirical investigation) is briefly mentioned but the research did not classify each item in the dataset according to these types.

Other quality assessments involve the review and classification of each individual publication in the literature stream. For example, Gattoufi et al. (2004) conducted a quality assessment of data envelopment analysis publications and classified them based on their nature (application versus theory) and the research strategy type (Ripple, Embedding, Transfer of Technology, Bridging, Creative Application, Structuring, or Statistical Modeling). Nissen (1996) created a framework to categorize business processing reengineering publications according to five classes: Trade Press, Redesign Cases, Expert Reengineering Methodologies, Academic Investigations, and Theory-Testing Works.

The present research did not include a citation/co-citation analysis in part because of the lack of academic literature in the Kaizen event body of knowledge to date. It was expected that a majority of the Kaizen event publications would be practitioner resources, so the classification

approach was chosen. In choosing the most appropriate classification approach for the dataset, it was observed that many of the selected publications for this Kaizen event systematic literature review were void of any research methods, did not present data, and were not theory-based. Therefore, categorizing these publications by application versus theory (i.e., Gattoufi et al., 2004) yielded very little additional information. Therefore, an adaptation of Nissen's framework (1996) was chosen as the most informative for categorizing the publications in the Kaizen event research stream. Table 2 reviews the categories and provides the detailed criteria used to categorize each publication in the dataset.

Table 2. Classifications for Kaizen Event Research Dataset (adapted from Nissen, 1996)

Class of Publication	Criteria
Trade Press	• Shallow coverage of topic • Contributes little specific knowledge
Case Studies	• Descriptive works of Kaizen events and their general processes • Still little specific knowledge gained
Expert Kaizen Event Methodologies	• Includes practitioner guides to Kaizen events (steps and their order), including specific prescriptions for practice • Usually produced by consultants in the area
Academic Investigations	• Knowledge creation through the creation of frameworks and guidelines through defensible, extensible, and replicable research that begins to answer operationalized questions such as how to accomplish the steps of a Kaizen event • Includes works that generate hypotheses for further research (e.g., qualitative research and research that presents a working theory of a phenomenon, but does not test the hypotheses presented are academic investigations) • A case study conducted by an academician that follows a systematic qualitative research method is still categorized as an academic investigation
Theory-TestingWorks	• Explanatory and predictive knowledge to answer why or when Kaizen events are successful in certain instances • Must include hypothesis testing (all other academic studies are classified as academic investigations)

The author completed a quality assessment using Nissen's classification approach on the 80 new Kaizen event-specific studies found through the systematic literature search and the pre-

existing list of 72 Kaizen event publications (Farris, 2006) to gain a more in-depth picture of the current state of the maturity of the research stream (n=152). This dataset includes works published from January 1993 to December 2009. Approximately 15 authors from the dataset had more than two publications each. The OSU-VT research team authored the most publications (24). Four out of the 152 publications are books or Kaizen event manuals, while most publications are in practitioner periodicals.

The percentage of each Kaizen event publication type is illustrated in Figure 3. The *Case Study* is the most frequent form of Kaizen event publication in the dataset (36%). Boeing, Dana Corporation, and Freudenberg-NOK were frequent case study examples (e.g., Cuscela, 1998; Vasilash, 1997). The *Expert Kaizen Event Methodologies* (13%) were fairly consistent in emphasizing some Kaizen event characteristics; for instance, cross-functional teams and action orientation were important (e.g., Martin and Osterling, 2007; Mika, 2002). However, there was dissention among some of the more specific prescriptions, e.g., encouraging management (Martin, 2007) or not allowing management (e.g., Huls, 2005) to participate in events. Many of the *Academic Investigations* (27%) were academician-conducted case studies that focused on providing practitioner-focused insights and on developing hypotheses for future research (e.g., Magdum and Whitman, 2007). The works of Bateman (e.g., 2005), Miller (2005), Patil (2003), and the OSU-VT Kaizen event research efforts comprise the *Theory Testing* publications that focused on hypotheses testing (7%) and are reviewed in Sections 2.2 and 2.4. A complete categorization list is provided in Appendix A and a list of the publications reviewed is provided in Appendix B.
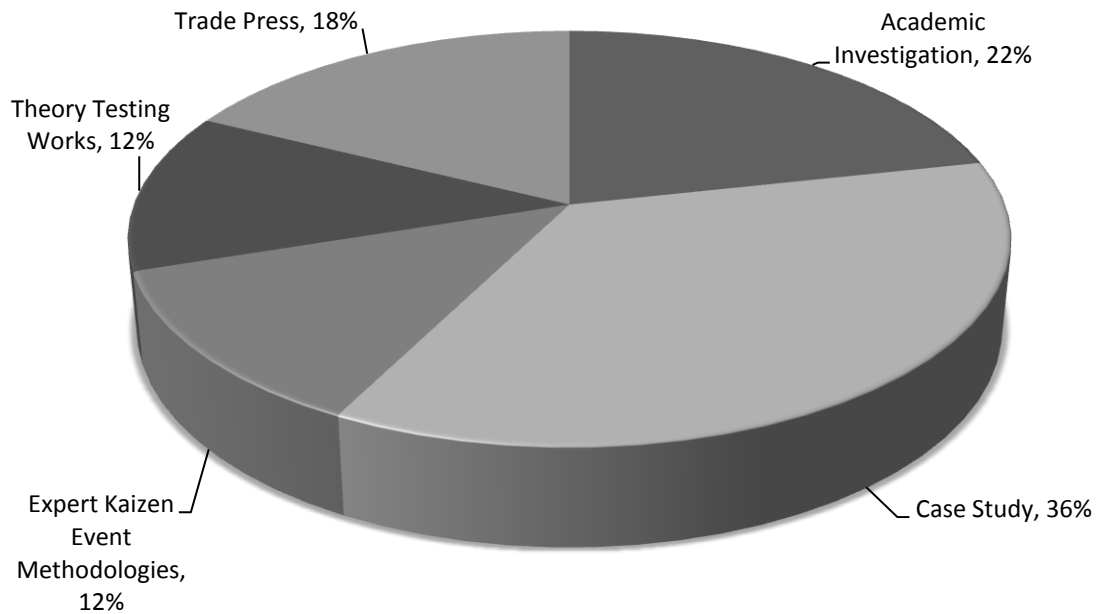
Figure 3. The Types of Publications from the Systematic Review Dataset

This quality assessment can also be used to assess the Kaizen event research stream's maturity. The maturity of any research stream can be determined by a number of indicators. To obtain a general idea of an area's maturity, one can examine the number of textbooks published in a field or examine the extent to which the field is being applied to other areas (Gattoufi et al., 2004). Field maturity can be assessed by the depth of its research content and its degree of relevance to global industry practices (Sheldon, 2006). One publication that assessed the maturity of the information systems field considered three maturity characteristics (Cheon et al., 1993):

- Integration of a diverse set of variables (both explanatory factors and outcomes) to solidify a standard, paradigm, or model
- Use of multiple methodologies within the field
- Explanation of phenomena through hypothesis testing with generalizable and inferential methodologies

Review of the Kaizen event literature reveals that the literature does converge to support some practices which would suggest that a standard paradigm of Kaizen event practice is developing. Examples of converging ideas in the literature are:

- focus on waste elimination (e.g., Boyer, 2002)

- the use of cross-functional teams (e.g., Lewis, 2007)

- including some "fresh eyes" – people with no prior knowledge of the target area – on the team (e.g., LeBlanc, 1999).

- management support and buy in (e.g., Miller, 2004)

- rewards and recognition of the team after the event (e.g., Martin and Osterling, 2007)

- action orientation (e.g., Melnyk et al., 1998)

- involving first hand observation of the target area (e.g., Mika, 2002)

Many of these converging ideas have been included in *Academic Investigations* and *Theory-Testing* works (e.g., Melnyk et al., 1998; Montabon et al., 2005). However, there is disagreement among some of the more specific prescriptions. Many of the divergent prescriptions are from *Case Study* and *Trade Press* articles. Some examples are:

- encouraging management (Martin, 2007) versus not allowing management (e.g., Huls, 2005) to participate in events.

- including people from the work area on the Kaizen event team (e.g., DeFilippo, 1996) versus having a majority of the team members from outside of the targeted work area to prevent bias (Palmer, 2001).

- Having a 'lack of extensive planning' done before the event (e.g., Montabon et al., 1997) versus three days of planning (Goldacker, 2005).

While some of the diverging topics, such as the importance of the Kaizen event planning process, have been studied by Kaizen event researchers (e.g., Farris, 2006), there is still a limited amount of empirical research in the area. Additional research from more authors using multiple models and methodologies to study these diverging topics would indicate a greater level of maturity in the field. Qualitative research, typically of a single case study organization, is the dominant methodology among the current Kaizen event academic studies. And while some quantitative studies have been performed (e.g., Bateman, 2005; Burch, 2008; Farris et al., 2009), there have been few quantitative approaches used to study Kaizen events to date. Operations management researchers emphasize the importance of using both rigorous qualitative and

quantitative methods from various ontological and epistemological perspectives in empirical research in order to advance the knowledge and theory of an area of study (e.g., Meredith, 1998; Roth, 2004). However, the body of knowledge regarding similar phenomena shows that there are still a limited number of methodologies used. For example, while general process improvement sustainability research has included multiple approaches from the use of multiple case studies (Oxtoby et al., 2002) to system dynamics (e.g., Keating et al., 1999), the methods are still largely qualitative. This may suggest that the need to explore multiple qualitative and quantitative methodologies in the study of improvement phenomena may not be limited to Kaizen events. Furthermore, there may be some inherent difficulties regarding the quantitative study of such phenomena that limit the types of methods that can be used.

In summary, the Kaizen event research stream is still very young; the dataset's earliest citation was published in 1993. The field is dominated by trade press and case study works that contribute limited specific knowledge to the understanding of Kaizen events. In fact, 67% of the published Kaizen event works are not academic in nature. Finally, because there is only a small group of authors of the *Academic Investigations* and *Theory-Testing* publications (e.g., Farris et al., 2009; Bateman, 2005), the research stream has a limited set of variables, models, and methodologies to explain the phenomena. However, in recent years, the number of Kaizen event studies has expanded to a larger set of authors (e.g., Burch, 2008; Marin-Garcia et al., 2009). Furthermore, the study of Kaizen events appears to be expanding to a more diverse set of industries, including healthcare (e.g., Adamson and Kwolek, 2008; Martin et al., 2009) and the public sector (e.g., Randor and Walley, 2008; Barraza et al., 2009). To continue this advancement of the Kaizen event research stream, future research should include more systematic academic investigations and theory-testing works. The following sections present a brief review of the Kaizen event literature in general (Section 2.2) and the findings of the OSU-VT research that relate to the immediate success of Kaizen events (Section 2.3). Next, a review of the literature related to the sustainability of Kaizen event outcomes (Section 2.4) as well as the key process improvement, continuous improvement, and organizational change articles (Sections 2.5 and 2.6) that informed the research model are presented.

2.2 Kaizen Event Literature

A Kaizen event is "a focused and structured improvement project, using a dedicated cross-functional team to improve a targeted work area, with specific goals, in an accelerated timeframe" (Farris et al., 2009, p.1). A Kaizen event is also known as a "rapid improvement event," "accelerated improvement workshop," and "Kaizen blitz" (Melnyk et al., 1998; Cuscela, 1998; Martin, 2007; Alexander and Williams, 2005).

Depending on a company's Kaizen event program structure, the Kaizen event can be comprised of several stages. The typical phases of a Kaizen event are: "(1) training; (2) documentation of the process 'as is'; (3) identification of potential opportunities for improvement; (4) an iterative and immediate process of introducing enhancements and assessing the effectiveness of these enhancements; (5) presentation of results (typically to management); and (6) generation of the 'action list' for follow-up interventions" (Melnyk et al., 1998, p. 70). Table 3 presents the Kaizen event characteristics and practices found across the Kaizen event body of knowledge as identified through the systematic literature presented in Section 2.1 (n=152) according to the following categories: *Task, Team, Organization, Event Process*, and *Broader Context*.

With respect to *Task*, many publications suggest a Kaizen event duration of one week or shorter (e.g., Lanigan, 2004) and emphasize waste elimination (e.g., Boyer, 2002). Some publications cite Kaizen events as an integral part of lean (e.g., Baker, 2003) or lean sigma (e.g., Cross, 2007). Two publications focus on use of Kaizen events to create more value, as opposed to its more traditional role of removing non-value added activities (Dickerson and Turner, 1999; Hale and Kubiak, 2007). The implementation authority of Kaizen event teams is emphasized across a large number of publications (e.g., Minton, 1998; LeBlanc, 1999; Alukal, 2006; Sprovieri, 2008). Specific examples of other forms of authority given to a team included the ability to appoint the team leader (e.g., Palmer, 2001) and the authority to identify the targeted improvements for the Kaizen event (e.g., Wittenberg, 1994). Generally, a well-defined (e.g., Mika, 2002) and properly scoped (e.g., Doolen et al., 2008) problem for targeted improvement is advised. However, recommendations regarding Kaizen event goals are somewhat varied; for example, some recommend that organizations should select goals that avoid complicated problems (e.g., Sheridan, 1997), while others recommend using challenging "stretch" goals (e.g., LeBlanc, 1999). Organizations may wish to select events based on their strategic direction (e.g.,

LeBlanc, 1999), based on analysis such as value stream mapping (e.g., Heard, 1997), or based on emerging problems (e.g., Watson, 2002).

In the *Team* category, several publications emphasize the use of cross-functional teams (e.g., Lewis, 2007), the use of external consultants as facilitators (e.g., Proctor, 1997), and the inclusion of people from the work area on the Kaizen event team (e.g., DeFilippo, 1996). The levels and types of cross-functionality vary from having work area employees account for the majority of the Kaizen event team (e.g., Tanner and Roncarti, 1994) to having employees from other areas account for the majority of the Kaizen event team in order to prevent bias (Palmer, 2001). In some Kaizen events, team members may also include customers (e.g., Vasilash, 1997; Martin et al., 2009) and suppliers (e.g., McNichols et al., 1999; Baken 2003). Recommendations for size of the Kaizen event team vary from three to five people (e.g., Rusiniak, 1996) to up to fifteen people (e.g., Laraia, 1998). Finally, a number of publications encourage the involvement of management on the Kaizen event team (e.g., Taylor and Ramsey, 1993; Cuscela, 1998; Martin, 2007), while others suggest that managers should not be directly on the Kaizen event team, but should instead be 'cheerleaders' of the team, encouraging their efforts in order to prevent the chance that employee participation could be limited by management participation (Huls, 2005; Sprovieri, 2008).

In *Organization*, management support and buy-in (e.g., Miller, 2004) and rewards and recognition of the team after the event (e.g., Martin and Osterling, 2007) are common practices. While human resource support is a frequent recommendation (e.g., Melnyk et al., 1998) and it is generally advised that team members be dedicated only to Kaizen event during its duration (e.g., Minton, 1998; Martin, 2004), some publications discuss the difficulties that can occur with reassigning production staff, even temporarily, to improvement activities; these difficulties can be counteracted by using a variety of strategies, including having shorter meetings (1 to 3 hours) during the week on production days and conducting bulk Kaizen event work during non-production days (Dentz et al., 2009). Varied recommendations are observed regarding event planning. For example, some suggest that a lack of extensive planning may be beneficial in order to allow for new ideas and perspectives to arise from the Kaizen event activities (e.g., Montabon et al., 1997). Alternatively, others suggest as much as three full days of planning (Goldacker, 2005).

In the *Event Process* category, action orientation (e.g., Bicheno, 2001), first-hand observation of the targeted work area for activities such as data collection (e.g., Boyer, 2002), and documentation of the current and future process (e.g., Nahmens, 2009) are common practices across the publications. Many emphasize the use of multiple problem solving techniques, depending on the targeted improvement, including general approaches such as brainstorming (e.g., Cuscela, 1998) to more specific tools such as Pareto charts (e.g., Barraza et al., 2009). Generally, a report-out meeting to management after the Kaizen event is used, in part as a way to emphasize management's support of the improvement effort (e.g., Adams et al., 1997; Adamson and Kwolek, 2008).

The *Broader Context* of Kaizen events includes the use of Kaizen events to empower employees (e.g., Palmer, 2001), to train upper management on lean (Koenigsaecker, 2005), and to prevent outsourcing (e.g., Lanigan, 2004). Activities to follow-up on the outcomes of a Kaizen event include the use of follow-up meetings (Martin and Osterling, 2007), 30, 60, and 90-day follow-up reports to management (Goldacker, 2005), the definition of measures aligned with event goals to track whether improvements are sustained (e.g., Vitalo et al., 2003), the use of charts and other metric displays in the work area to sustain results (e.g., Bateman, 2005), having team members share lessons learned with all other work area and process employees. (e.g., Mika, 2002; Vitalo et al., 2003), and following Kaizen events with "traditional" kaizen (CPI) activities (David, 2003). Practices of organization-wide Kaizen event programs include the management of facilitator expertise, the management of leader expertise, clear administration of the program, and the importance of a defined and managed budget. For example, the use of external consultants to begin the Kaizen event program through facilitation (e.g., Martin, 2004), the use of the facilitator expertise to determine the tools and problem solving methods needed during an event (Heard, 1997), and the use of standard training materials for training team leaders (Vitalo et al., 2003) are among the recommendations observed in the publications. Other *Broader Context* recommendations include the designation an event administrator (Mika, 2002), the creation of organizational policies that support the Kaizen event program (e.g., Tanner and Roncarti, 1994), and the adequate provision of resource support (e.g., Minton, 1998).

In the first phase of the broader OSU-VT Kaizen event research initiative (Farris, 2006), researchers studied *Task, Team, Organization*, and *Event Process* practices to determine the critical factors related to initial Kaizen event success (Farris, 2006). The next section (2.3)

summarizes those results and how they informed the present research on Kaizen event sustainability. The *Broader Context* practices reported by practitioners and researchers to address the sustainability of Kaizen events are discussed in greater detail in Section 2.4.

Table 3. Kaizen Event Practices Identified from Systematic and Previous (Farris, 2006) Literature Reviews

I.   **Task** -- Task Design Factors (Cohen and Bailey, 1997), Project Level Antecedents (Nicolini, 2002), and Factors Related to Project (Belassi and Tukel, 1996)

    a.   Event Duration

        1.   One week or shorter (*LeBlanc, 1999; Oakeson, 1997; Vasilash, 1997; Drickhamer, 2004b; Watson, 2002; Smith, 2003; Cuscela, 1998; McNichols et al., 1999; Martin, 2004; Sheridan, 1997; Patton, 1997; Bradley and Willett, 2004; Vasilash, 1993; Bicheno, 2001; Adams et al., 1997; Melnyk et al., 1998; Sheridan, 2000a; Heard, 1997; Pritchard, 2002; Klaus, 1998; Clark, 2004; David, 2000; Wittenberg, 1994; "Get Smart, Get Lean," 2003; Sabatini, 2000; Tanner and Roncarti, 1994; Larson, 1998a; "Waste Reduction Program Slims Fleetwood Down," 2000; Kumar and Harms, 2004; David, 2003; Taylor and Ramsey, 1993; Martin, 2007; Ortiz, 2006; Venables, 2005; Cveykus and Carter, 2006; Diana, 2005; Vonk, 2005; Mika, 2002; Vitalo et al., 2003; Scheel and Zimmerman, 2007; Johnson et al., 2007; Cunningham and Smith, 2007; Harms, 2007; Destefani, 2005; Lanigan, 2004; Liu, 2008; Boyer, 2002; Montabon et al., 1997; Magdum and Whitman, 2007; Martin and Osterling, 2007; "Business Stationary Completes First Lean Kaizen Event"; Barraza et al., 2009; Sprovieri, 2008; Dentz et al., 2009; Martin et al., 2009*)

        2.   Two weeks or shorter (*Minton, 1998; Demers, 2002; Harvey, 2004; Foreman and Vargas, 1999; Wickiser, 2007*)

    b.   Team Authority/Autonomy

        1.   Teams have implementation authority (*LeBlanc, 1999; Oakeson, 1997; Minton, 1998; Martin, 2004; Sheridan, 1997; Bradley and Willett, 2004; Bicheno, 2001; Adams et al., 1997; Melnyk et al., 1998; Pritchard, 2002; Klaus, 1998; Wheatley, 1998; Laraia, 1998; "Get Smart, Get Lean," 2003; Sabatini, 2000; Tanner and Roncarti, 1994; Larson, 1998a; Treece, 1993; "Waste Reduction Program Slims Fleetwood Down," 2000; Kumar and Harms, 2004; Taylor and Ramsey, 1993; Foreman and Vargas, 1999; Cuscela, 1998; Mika, 2002; Alukal, 2006; Montabon et al., 1997; "Business Stationary Completes First Lean Kaizen Event," 2009; Sprovieri, 2008*)

        2.   Team controls starting and stopping times of Kaizen event activities – often, long days 12-14 hrs (*Sheridan, 1997; Vasilash, 1993; Larson, 1998b; Tanner and Roncarti, 1994; Kumar and Harms, 2004*)

        3.   Team members participate in setting improvement goals and assigning team roles (*Heard, 1997*)

        4.   Team has considerable control over the activities they adopt in meeting event goals (*Wheatley, 1998; Larson, 1998a; Tanner and Roncarti, 1994; Montabon et al., 1997*)

        5.   Team identifies own improvement opportunities and targets (*Wittenberg, 1994*)

        6.   Team appoints own leader (*Wittenberg, 1994; Palmer, 2001*)

        7.   Team leader participates in setting goals (*Tanner and Roncarti, 1994*)

        8.   Problem scope can be shrunk or expanded during the Kaizen event (*Tanner and Roncarti, 1994*)

        9.   Team selects target area (*Kumar and Harms, 2004*)

      10. Team autonomy is positively related to team member perceptions of their Kaizen capabilities and the impact of the Kaizen event on the work area (*Farris, 2006; Farris et al., 2009*)

    c.   Problem Scope

        1.   Require a standard, reliable target process/work area as input (*LeBlanc, 1999; Bradley and Willett, 2004; Martin, 2007; Mika, 2002; Huls, 2005; Vitalo et al., 2003*)

        2.   Requires a well-defined problem statement as input *(Rusiniak, 1996; Adams et al., 1997; Montabon, 2005; Mika, 2002; Goldacker, 2005)*

        3.   Avoid problems that are too big and/or emotionally involved (*Rusiniak, 1996; Sheridan, 1997; "Get Smart, Get Lean," 2003; David, 2003*)

        4.   Preference given to Kaizen events that require simple, well-known tools versus more

complex tools (*Bradley and Willett, 2004*)

5. Avoid problems that require advanced statistical analysis (*Harvey, 2004*)
6. Can be used for process design (*Harvey, 2004*)
7. A problem scope that is too broad may negatively influence Kaizen event outcomes and sustainability (*Doolen et al., 2008; Burch, 2008*)

d. Event Goals

1. Linked to organizational strategy *(LeBlanc, 1999; "Keys to Success," 1997; Melnyk et al., 1998; "Get Smart, Get Lean," 2003; Montabon, 2005; Mika, 2002; Goldacker, 2005; Vasilash, 2000; Patil 2003; Radnor and Walley, 2009)*
2. Challenging "stretch" goals (*LeBlanc, 1999; Minton, 1998; Rusiniak, 1996; Cuscela, 1998; Bradley and Willett, 2004; Bicheno, 2001; Tanner and Roncarti, 1994; Treece, 1993; Kumar and Harms, 2004; David, 2003; Martin and Osterling, 2007*)
3. Focused – on a specific process, product, or problem *(Minton, 1998; Drickhamer, 2004b; Martin, 2004; Sheridan, 1997; Bicheno, 2001; Adams et al., 1997; Melnyk et al., 1998; Heard, 1997; David, 2000; Laraia, 1998; Tanner and Roncarti, 1994; Montabon, 2005; "Scanning CMM: Increases Productivity," 2005; Palmer, 2001; Montabon et al., 1997; Martin and Osterling, 2007; Bateman, 2005; Sprovieri, 2008)*
4. Concrete, measurable goals (*Martin, 2004; Bradley and Willett, 2004; Vasilash, 1993; Melnyk et al., 1998; Heard, 1997; Treece, 1993; "Waste Reduction Program Slims Fleetwood Down," 2000; Foreman and Vargas, 1999; "Scanning CMM: Increases Productivity," 2005*)
5. Used as a part of lean practices and implementation (*Vasilash, 1997; Baker, 2003; Blake and Eash, 2003; Boyer, 2002; Cork, 2004; Destefani, 2005; Koenigsaecker, 2005; Langer, 2007; Lee, 2007; Lewis, 2007; Miller, 2004; Loyd et al., 2009; Radnor and Walley, 2008*)
6. Focus on implementation of lean sigma practices(*Cross, 2007; Tatikonda, 2008; Lanigan, 2004; Gaboury, 2007; "Business Stationary Completes First Lean Kaizen Event," 2009*)
7. Emphasis on the needs of the external customer – e.g. improving value – versus internal efficiency (*Melnyk et al., 1998; Laraia, 1998; Tatikonda, 2008*)
8. Emphasis on waste elimination (*Watson, 2002; Cuscela, 1998; Martin, 2004; Patton, 1997; Adams et al., 1997; Heard, 1997; Klaus, 1998; David, 2000; Wittenberg, 1994; "Get Smart, Get Lean," 2003; Tanner and Roncarti, 1994; "Waste Reduction Program Slims Fleetwood Down," 2000; Kumar and Harms, 2004; Taylor and Ramsey, 1993; Foreman and Vargas, 1999; Martin, 2007; Harms, 2007; "What Next After the Kaizen Blitz," 1999; Baker, 2003; Boyer, 2002; Goldacker, 2005; Hale and Kubiak, 2007; Lanigan, 2004; Manos, 2007; Montabon et al., 1997; Palmer, 2001; Proctor, 1997; Martin and Osterling, 2007; Barraza et al., 2009; Blanchard, 2009; Rumpza, 2009; Martin et al., 2009; Nahmens, 2009; Radnor and Walley, 2008*)
9. Emphasis on improving flow (*Tanner and Roncarti, 1994; Baker, 2003*)
10. Emphasis on ergonomic or safety improvements *(Vitalo et al., 2003; Montabon et al., 1997; Harms, 2007; Rumpza, 2009)*
11. Emphasis on creating more value (*Hale and Kubiak, 2007; Dickerson and Turner, 1999*)
12. Goal difficulty is positively related to team member perceptions of their Kaizen capabilities and negatively related to goal achievement and team member perceptions of the impact of the Kaizen event on the work area (*Farris, 2006; Farris et al., 2009*)
13. Goal clarity is positively related to team member perceptions of their Kaizen capabilities and attitudes toward Kaizen events (*Farris, 2006; Farris et al., 2009*)

II. **Team** -- Group Composition Factors (Cohen and Bailey, 1997), Project Level Antecedents (Nicolini, 2002), and Factors Related to the Project Team (Belassi and Tukel, 1996)

a. Team size

1. 3 – 5 people (*Rusiniak, 1996*)
2. 6 – 10 people (*McNichols et al., 1999; Martin, 2004; Vasilash, 1993; Tanner and Roncarti, 1994 ; Martin, 2007; Chapman, 2006; Kumar, 2004; Mika, 2002; Alukal, 2006; Vasilash, 2000; White, 2000; Sprovieri, 2008; Laraia, 1998; Sabatini, 2000*)

3. 10 – 15 people (*LeBlanc, 1999; Demers, 2002; Watson, 2002; Pritchard, 2002; Treece, 1993; Larson, 1998b; Cuscela, 1998; Cveykus and Carter, 2006; Laraia, 1998; Sabatini, 2000*)
b. Use of Cross-Functional Teams (*LeBlanc, 1999; Drickhamer, 2004b; Rusiniak, 1996; Demers, 2002; Smith, 2003; Cuscela, 1998; McNichols et al., 1999; Martin, 2004; Sheridan, 1997; Vasilash, 1993; Vasilash, 1993; Adams et al., 1997; Melnyk et al., 1998; Sheridan, 2000a; Pritchard, 2002; Laraia, 1998; Harvey, 2004; Foreman and Vargas, 1999; Martin, 2007; Montabon, 2005; Venables, 2005; Chapman, 2006; Huls, 2005; Wickiser, 2007; Alukal, 2006; Harms, 2007; Dickerson and Turner, 1999; Goldacker, 2005; Lanigan, 2004; Lewis, 2007; Vasilash, 2000; Magdum and Whitman, 2007; Martin and Osterling, 2007; Patil, 2003; Rumpza, 2009; Dentz et al., 2009; Adamson and Kwolek, 2008; Martin et al., 2009; Marin-Garcia et al., 2009*)
c. Team Structure
1. Informal "floating" team structure (*Adams et al., 1997*)
2. Team members volunteer to participate (*Watson, 2002; Adams et al., 1997; Defilippo, 1996*)
3. No rank of team members, 1 person, 1 vote (*Mika, 2002*)
4. Using a leader and co-leader or sub-leader (*White, 2000; Tanner and Roncarti, 1994*)
5. Team leader and sub-team leader are selected by the business unit manager (*Tanner and Roncarti, 1994*)
6. Using a Kaizen event champion, e.g., executive sponsor (*Ortiz, 2006; Adamson and Kwolek, 2008*)
7. Kaizen Champion same on all events, a lean engineer (*Ortiz, 2006*)
8. The event champion positively influences Kaizen event outcome sustainability (*Bateman, 2005*)
d. Functional Heterogeneity
1. Including "fresh eyes" – people with no prior knowledge of the target area – on the team (*LeBlanc, 1999; Vasilash, 1997; Kleinsasser, 2003; Minton, 1998; Cuscela, 1998; McNichols et al., 1999; Martin, 2004; Bradley and Willett, 2004; Melnyk et al., 1998; David, 2000; Foreman and Vargas, 1999; Martin, 2007; Chapman, 2006; Huls, 2005; Mika, 2002; Sprovieri, 2008*)
2. Including people from the work area on the Kaizen event team (*Redding, 1996; Minton, 1998; Womack and Jones, 1996a; Martin, 2004; Sheridan, 1997; Bradley and Willett, 2004; Vasilash, 1993; Bicheno, 2001; Adams et al., 1997; Melnyk et al., 1998; Heard, 1997; David, 2000; Wheatley, 1998; Tanner and Roncarti, 1994; Treece, 1993; Taylor and Ramsey, 1993; Cuscela, 1998; Martin, 2007; Montabon, 2005; Huls, 2005; Mika, 2002; "What Next After the Kaizen Blitz," 1999; Defilippo, 1996 ; Flint, 2007; Boyer, 2002; Goldacker, 2005*)
3. Most team members are from work area (*Tanner and Roncarti, 1994*)
4. Most team members are from outside areas to prevent bias (*Palmer, 2001*)
5. Including people from all production shifts in Kaizen event team (*Vasilash, 1993*)
6. Each team member has specific knowledge of the process (*Watson, 2002*)
7. Each team member is either directly or indirectly involved in the target process (*Kumar and Harms, 2004; Sprovieri, 2008*)
8. Including people from all functions required to implement/sustain results on the Kaizen event team (*Bradley and Willett, 2004; Vasilash, 1993; Adams et al., 1997*)
9. Including subject matter experts (SMEs) – e.g., quality engineers. Maintenance – on the team (*David, 2000; Treece, 1993; Taylor and Ramsey, 1993; Sprovieri, 2008*)
10. Including only one employee per department on the Kaizen event team, except for the department being blitzed, to avoid over-burdening any department (*Minton, 1998*)
11. Including managers and supervisors on the Kaizen event team (*Oakeson, 1997; "Keys to Success," 1997; Vasilash, 1993; Bicheno, 2001; Heard, 1997; Clark, 2004; David, 2000; "Get Smart, Get Lean," 2003; Sabatini, 2000; Tanner and Roncarti, 1994; Treece, 1993; Taylor and Ramsey, 1993; Cuscela, 1998; Martin, 2007; Defilippo, 1996*)
12. Including target area supervisor on Kaizen event team (*Patton, 1997*)

13. Including the targeted process owner throughout the Kaizen event process (*Adamson and Kwolek, 2008*)
14. Including customers on the Kaizen event team (*Hasek, 2000; Vasilash, 1997; McNichols et al., 1999; Vasilash, 1993; Adams et al., 1997; Melnyk et al., 1998; Heard, 1997; Larson, 1998b; Treece, 1993; Sprovieri, 2008; Martin et al., 2009*)
15. Including suppliers on the Kaizen event team (*Vasilash, 1997; McNichols et al., 1999; Vasilash, 1993; Adams et al., 1997; Melnyk et al., 1998; Heard, 1997; "Get Smart, Get Lean," 2003; Tanner and Roncarti, 1994; Larson, 1998b; Baker, 2003; Cross, 2007; Sprovieri, 2008*)
16. Including benchmarking partners or other external non-supply chain parties on the Kaizen event team (*McNichols et al., 1999; Sheridan, 1997; Vasilash, 1993; "Get Smart, Get Lean," 2003*)
17. Including people from other sister plants or corporate headquarters on the team (*Sabatini, 2000; Tanner and Roncarti, 1994*)
18. Avoid including people from competing plants or functions on the Kaizen event team (*Bradley and Willett, 2004*)
19. No managers/process owners as decision makers, only as 'cheerleaders' (*Huls, 2005; Sprovieri, 2008*)
20. Leader is outsider, not biased (Montabon, 2005)
21. The functional heterogeneity of an event is negatively related to team member perceptions of their attitudes toward Kaizen events (*Farris, 2006; Farris et al., 2009*)

e. Facilitator, Team Leader, and Team Member Problem-Solving Abilities
1. Black Belts assigned to Kaizen event teams for Lean-Six Sigma programs (*Sheridan, 2000b; Cveykus and Carter, 2006*)
2. At least one member of Kaizen event team experienced enough in tool(s) to teach others (*Bradley and Willett, 2004; Mika, 2002*)
3. Including outside consultants on the Kaizen event team, e.g., for the first few Kaizen events (*Oakeson, 1997; Bicheno, 2001; Sabatini, 2000; "Waste Reduction Program Slims Fleetwood Down," 2000; Kumar and Harms, 2004; Cuscela, 1998; Kumar, 2004; Martin, 2007; Mika, 2002; Venables, 2005; Dickerson and Turner, 1999; Proctor, 1997; White, 2000; Barraza et al., 2009; Rumpza, 2009; Marin-Garcia et al., 2009*)
4. Facilitators are experienced, knowledgeable, and understand the underlying philosophy of lean (*Lee, 2007; Sprovieri, 2008*)
5. The Kaizen experience of team members and leaders is negatively related to goal achievement and team member perceptions of their Kaizen capabilities (*Farris, 2006; Farris et al., 2009*)
6. The Kaizen experience of team leaders positively influences Kaizen event outcome sustainability (*Bateman, 2005*)
7. Facilitator participation in decision-making may positively influence team member-participation in decision-making and may positively influence Kaizen event outcomes and sustainability (*Burch, 2008*)

f. Team Member Attitudes and Commitment
1. Team members are positive thinkers (*"Get Smart, Get Lean," 2003; Martin et al., 2009*)
2. Team members have a sense of accountability to the organization (*Adamson and Kwolek, 2008*)
3. The interest/enjoyment of team members during a Kaizen event may influence Kaizen event outcomes (*Miller, 2004*)
4. The affective commitment to change is positively related to team member perceptions of their Kaizen capabilities (*Farris, 2006; Farris et al., 2009; Devens et al., 2008*)
5. The internal harmony of team members is positively related to team member perceptions of their Kaizen capabilities and their attitudes toward Kaizen events (*Farris, 2006; Farris et al., 2009; Devens et al., 2008*)

III. **Organization** -- Organizational Context Factors (Cohen and Bailey, 1997); Project Level Antecedents (Nicolini, 2002); Factors Related to the Organization (Belassi and Tukel, 1996)

    a. Management Support/Buy-In (*Bane, 2002; Hasek, 2000; Vasilash, 1997; Rusiniak, 1996; Cuscela, 1998; Martin, 2004; Sheridan, 1997; "Keys to Success," 1997; Bradley and Willett, 2004; Vasilash, 1993; Bicheno, 2001; Adams et al., 1997; Heard, 1997; Laraia, 1998; Tanner and Roncarti, 1994; Treece, 1993; "Waste Reduction Program Slims Fleetwood Down," 2000; Kumar and Harms, 2004; Taylor and Ramsey, 1993; Martin, 2007; Mika, 2002; Wickiser, 2007; Alukal, 2006; Baker, 2003; Dickerson and Turner, 1999; Boyer, 2002; Miller, 2004; Farris, 2006; Bateman, 2005; Sprovieri, 2008; Adamson and Kwolek, 2008; Doolen et al., 2008; Farris et al., 2009; Glover et al., 2008; Marin-Garcia et al., 2009*)

        1. Plant manufacturing director temporarily moves his/her office to Kaizen event room during event (*Tanner and Roncarti, 1994*)

        2. Business unit managers divide their time between the shop floor and the Kaizen event room during the event (*Tanner and Roncarti, 1994*)

        3. Use of a management guidance team to empower and support the Kaizen event team during and after the Kaizen event (*Boyer, 2002)*

        4. Management support is positively related to team member perceptions of the impact of the Kaizen event on the work area and their attitudes toward Kaizen events (*Farris, 2006; Farris et al., 2009*)

    b. Resource Support

        1. Team members dedicated only to Kaizen event during its duration (*Minton, 1998; McNichols et al., 1999; Martin, 2004; Bradley and Willett, 2004; Bicheno, 2001; Melnyk et al., 1998; Heard, 1997; Harvey, 2004; Kumar and Harms, 2004; David, 2003; Foreman and Vargas, 1999; Cuscela, 1998; Martin, 2007; Mika, 2002; Alukal, 2006; Harms, 2007; Sprovieri, 2008*)

        2. Having support personnel – e.g., maintenance, engineering, etc. – "on call" during the event, to provide support as needed – e.g., moving equipment overnight (*McNichols et al., 1999; Martin, 2004; Sheridan, 1997; Bradley and Willett, 2004; Bicheno, 2001; Adams et al., 1997; Wittenberg, 1994; Tanner and Roncarti, 1994; David, 2003; Taylor and Ramsey, 1993; Mika, 2002*)

        3. Use of a variety of strategies (e.g., conducting Kaizen event during nonproduction days) in order to account for a lack of human resource availability (*Dentz et al., 2009*)

        4. Low cost solutions (*Purdum, 2004; Cuscela, 1998; Martin, 2004; Sheridan, 1997; Vasilash, 1993; Bicheno, 2001; Adams et al., 1997; Melnyk et al., 1998; Klaus, 1998; Tanner and Roncarti, 1994; Larson, 1998a; Treece, 1993; Taylor and Ramsey, 1993; Martin and Osterling, 2007*)

        5. Cost is <u>not</u> a factor (*Minton, 1998*)

        6. Having a specified budget for expenditures associated with Kaizen events conducted across the organization (*Palmer, 2001*)

        7. Dedicated room for Kaizen event team meetings (*Creswell, 2001; Tanner and Roncarti, 1994; Martin, 2007; Montabon, 2005; Mika, 2002*)

        8. Snacks provided to team during Kaizen event (*Creswell, 2001; Adams et al., 1997; Martin, 2007; Mika, 2002*)

        9. Stopping production in target area during the Kaizen event (*Bradley and Willett, 2004*)

        10. Priority given to Kaizen team requests (*Kumar and Harms, 2004*)

        11. Use of a Kaizen cart containing tools and supplies that serves as a mobile office for the Kaizen event team during the event (*Taylor and Ramsey, 1993*)

        12. Resource support positively influences Kaizen event outcomes (*Devens et al., 2008*) and sustainability (*Bateman, 2005*)

    c. Rewards/Recognition

        1. Rewards and recognition for team after the event – e.g., celebrations (*Adams et al., 1997; Melnyk et al., 1998; Martin, 2004; Tanner and Roncarti, 1994; Larson, 1998b; Taylor and Ramsey, 1993; Foreman and Vargas, 1999; Huls, 2005; Vitalo et al., 2003; Mika, 2002; Montabon, 2005; Martin, 2007*; Goldacker, 2005; Miller, 2004; Martin and Osterling, 2007; Nahmens, 2009*)

        2. Keepsakes serve as recognition and advertisement – e.g. hats, shirts, jackets etc. (*Mika,*

2002; Vitalo et al., 2003)

    d.   Communication

        1. Importance of buy-in from employees in work area as well as other stakeholders *(Sheridan, 1997; Mika, 2002; Dentz et al., 2009; Adamson and Kwolek, 2008*)

        2. Discussion of changes with employees in the work area during the Kaizen event (*Wittenberg, 1994; Sabatini, 2000; David, 2003; Boyer, 2002; Bicheno, 2001; Mika, 2002*)

        3. Feedback forms filled out by each team member at the end of the event (*Mika, 2002*)

        4. Having meetings with other employees individually or in small groups to get feedback and buy-in to the changes (*Dentz et al., 2009*)

        5. Communication of changes made as a result of a Kaizen event positively influences Kaizen event outcome sustainability (*Patil, 2003; Bateman, 2005*)

    e.   Event Planning Process

        1. Well-defined and thorough event planning activities – i.e., adequate preparation (*Sheridan, 1997; Bradley and Willett, 2004; Heard, 1997; David, 2003; Foreman and Vargas, 1999; Mika, 2002; Boyer, 2002; Martin et al., 2009; Goldacker, 2005*)

        2. Lack of extensive planning done before event in order to allow for new ideas and perspectives to arise from the Kaizen event activities (*White, 2000; Montabon et al., 1997*)

        3. Including process documentation – e.g., VSM, process flowcharts, videotapes of the process, current state data, etc. – as input to Kaizen event (*Minton, 1998; McNichols et al., 1999; Martin, 2004; Bradley and Willett, 2004; Bicheno, 2001; David, 2000; Kumar and Harms, 2004; David, 2003; Mika, 2002; Johnson et al., 2007; Boyer, 2002; Dentz et al., 2009*)

        4. Involving employees in event planning (*Patil, 2003; Dentz et al., 2009*)

        5. Using a smaller core group of team members to do preparatory work and develop preliminary solutions (*Dentz et al., 2009*)

        6. Notifying employees in adjoining work areas before the start of the Kaizen event – e.g., publicizing the event (*McNichols et al., 1999; David, 2003; Mika, 2002*)

        7. Use of a Kaizen mandate – e.g., Kaizen event announcement – to clearly define and communicate event goals (*Heard, 1997; Foreman and Vargas, 1999; Vitalo et al., 2003*)

        8. Tools/problem solving method to be used are identified by the facilitator (*Heard, 1997*)

        9. Team leader prepares a briefing package with historical performance data, layout drawings, staffing data and customer requirements data before the event, which is given to the rest of the team on the first day of the event (*Tanner and Roncarti, 1994*)

     10. Development of an "event schedule" – i.e., a high-level road map of activities – before the event (*Foreman and Vargas, 1999; Boyer, 2002*)

     11. Need a project charter, with clear proposal, including purpose, scope, objectives etc. (*Montabon, 2005; Cveykus and Carter, 2006; Martin, 2007; White, 2000; Sprovieri, 2008*)

     12. Set milestones for the event (*Vitalo et al., 2003*)

     13. The number of hours spent planning is positively related to goal achievement *(Farris, 2006)*

    f.   Training

        1. Less than two hours of formal training provided to team (*Minton, 1998; McNichols et al., 1999; Montabon, 2005*)

        2. Including ½ day of training at the start of the event – i.e., training in tools, kaizen philosophy, etc. (*Vasilash, 1993; Melnyk et al., 1998; Heard, 1997; Klaus, 1998; David, 2000; Tanner and Roncarti, 1994; Treece, 1993; "Waste Reduction Program Slims Fleetwood Down," 2000; Foreman and Vargas, 1999; Wickiser, 2007*)

        3. Including 6 hours of training at the start of the event – i.e., training in tools, kaizen philosophy, etc. (*Montabon et al., 1997*)

        4. Including 1 day of training at the start of the event – i.e., training in tools, kaizen philosophy, etc. (*Wittenberg, 1994; "Get Smart, Get Lean," 2003; Larson, 1998b;*

"Waste Reduction Program Slims Fleetwood Down," 2000; Taylor and Ramsey, 1993; Foreman and Vargas, 1999; Scheel and Zimmerman, 2007; Cunningham and Smith, 2007; Palmer, 2001; Miller, 2004; "Business Stationary Completes First Lean Kaizen Event," 2009)

5. 2 days of training – i.e., training in tools, kaizen philosophy, etc. (*Mika, 2002*)
6. "Short courses" on topics can be provided "on the spot" for each activity or if the team gets stuck (*Minton, 1998; Huls, 2005*)
7. Team members who aren't from the process get training in the process and may even work in the production line for a few days before the Kaizen event (*Minton, 1998*)
8. Including teamwork or "team-building" exercises as part of Kaizen event training (*Bicheno, 2001; Foreman and Vargas, 1999; Vitalo et al., 2003; Marin-Garcia et al., 2009; Alukal, 2006; Gaboury, 2007*)
9. Including training on lean principles, e.g., the seven wastes (*Bicheno, 2001; Mika, 2002; Boyer, 2002; "Business Stationary Completes First Lean Kaizen Event," 2009; Barraza et al., 2009; Marin-Garcia et al., 2009; Alukal, 2006; Gaboury, 2007*)
10. Training can be provided before the formal start of the event – i.e., offline (*McNichols et al., 1999; Bicheno, 2001; David, 2003; Cunningham and Smith, 2007*)
11. Emphasis on training during a Kaizen event (*Montabon et al., 1997*)

IV. **Event Process** -- Internal Process Factors (Cohen and Bailey, 1997), Processes (Nicolini, 2002), and Project Manager's Performance on the Job (Belassi and Tukel, 1996)

a. Action Orientation (*LeBlanc, 1999; Redding, 1996; Smith, 2003; Martin, 2004; Sheridan, 1997; Patton, 1997; Vasilash, 1993; Bicheno, 2001; Adams et al., 1997; Melnyk et al., 1998; Sabatini, 2000; Tanner and Roncarti, 1994; Larson, 1998a; Treece, 1993; Taylor and Ramsey, 1993; Foreman and Vargas, 1999; Cuscela, 1998; Martin, 2007; Montabon et al., 1997; "Business Stationary Completes First Lean Kaizen Event," 2009*)

1. Involve first-hand observation of target area – e.g., data collection, etc. (*Smith, 2003; Vasilash, 1993; Clark, 2004; David, 2000; Wittenberg, 1994; Tanner and Roncarti, 1994; Larson, 1998b; Treece, 1993; "Waste Reduction Program Slims Fleetwood Down," 2000; Kumar and Harms, 2004; Taylor and Ramsey, 1993; Foreman and Vargas, 1999; Cuscela, 1998; Cveykus and Carter, 2006; Scheel and Zimmerman, 2007; Mika, 2002; Chapman, 2006; Cunningham and Smith, 2007; Vitalo et al., 2003;* Boyer, 2002; Palmer, 2001; Montabon et al., 1997)
2. Keep line running during Kaizen event, because it is important for the team to observe a running line (*Sheridan, 1997; Sabatini, 2000; Larson, 1998a; Tanner and Roncarti, 1994; Kumar and Harms, 2004; Scheel and Zimmerman, 2007*)
3. Cycles of solution refinement during Kaizen event (*Bradley and Willett, 2004; Bicheno, 2001; Melnyk et al., 1998; Clark, 2004; "Waste Reduction Program Slims Fleetwood Down," 2000; Taylor and Ramsey, 1993; Montabon et al., 1997*)
4. Training work area employees on the changes/new process as a part of the Kaizen event (*Martin, 2004; Heard, 1997; Martin, 2007; Mika, 2002; Patil, 2003*)
5. Experiment with improvement ideas and conduct a pilot (*Vitalo et al., 2003*)
6. Rapid decisions about changes are made during the event (*Martin and Osterling, 2007*)
7. Action orientation is positively related to team member perceptions of the impact of the Kaizen event on the work area and negatively related to goal achievement (*Farris, 2006*)

b. Problem Solving Tools/Techniques

1. Videotapes of setups (*Minton, 1998; Bradley and Willett, 2004*)
2. Brainstorming (*Minton, 1998; Watson, 2002; Martin, 2004; Bradley and Willett, 2004; Vasilash, 1993; Pritchard, 2002; Laraia, 1998; Kumar and Harms, 2004; Taylor and Ramsey, 1993; Cuscela, 1998; Mika, 2002; Montabon, 2005; Vitalo et al., 2003; Harms, 2007; Liu, 2008*)
3. Time studies/observations (*Blanchard, 2009; "Business Stationary Completes First Lean Kaizen Event," 2009*)
4. Avoid preconceived solutions (*Rusiniak, 1996; Bradley and Willett, 2004*)
5. Seek improvement, not optimization (*Rusiniak, 1996; Vasilash, 1993*)
6. Question the current process – ask why things are done the way they are (*Watson,*

2002; Minton, 1998; Taylor and Ramsey, 1993; Mika, 2002; Montabon, 2005)

7. Team should not be too rigid about sticking to formal methodology (*Bradley and Willett, 2004*)
8. Decisions are driven by hard/quantitative data (*Tanner and Roncarti, 1994; David, 2003; Alukal, 2006*)
9. Tools used depend on event goals – e.g., SMED, 5S, etc. (*Tanner and Roncarti, 1994*)
10. Draw spaghetti diagrams of the current process (*Martin, 2007; Cveykus and Carter, 2006; Mika, 2002; White, 2000*)
11. Follow Plan, Do, Check, Act (PDCA) process during event (*Gaboury, 2007*)
12. Conduct interviews of process owners (*Huls, 2005*)
13. Videotapes of process (Mika, 2002)
14. Map/Document the current and future process (*Vonk, 2005; Mika, 2002; Kumar, 2004; Huls, 2005; Harms, 2007; Cunningham and Smith, 2007; Johnson et al., 2007; Wickiser, 2007; Boyer, 2002; Goldacker, 2005; Lewis, 2007; Liu, 2008; Palmer, 2001; Patil, 2003; Nahmens, 2009*)
15. Have a final presentation at the end of the event (*Vitalo et al., 2003; Boyer, 2002; Liu, 2008; Montabon et al., 1997; Palmer, 2001; Adamson and Kwolek, 2008; Nahmens, 2009; Marin-Garcia et al., 2009*)
16. Creating a video report-out (*Sabatini, 2000*)

c. Team Coordination
1. At least one member of Kaizen event team keeps the team "on track" – i.e., focused (*Bradley and Willett, 2004; Vasilash, 1993; Wheatley, 1998; Foreman and Vargas, 1999; Martin, 2007l; Palmer, 2001*)
2. Use of subteams (*Minton, 1998; McNichols et al., 1999; Sheridan, 1997; Bicheno, 2001; Sabatini, 2000; Treece, 1993; Foreman and Vargas, 1999; Palmer, 2001*)
3. Use of a Kaizen newspaper/30-day action item list to capture needed actions that cannot be implemented during the Kaizen event (*"Winning with Kaizen," 2002; McNichols et al., 1999; Martin, 2004; Bradley and Willett, 2004; Melnyk et al., 1998; Heard, 1997; Larson, 1998a; Treece, 1993; Tanner and Roncarti, 1994; David, 2003; Magdum and Whitman, 2007; Martin et al., 2009*)
4. Team reviews current progress to plan next day's activities (*Wheatley, 1998; Sabatini, 2000*)
5. Every 2 – 3 hours, team reassembles in Kaizen event room to review progress and then returns to the target work area (*Tanner and Roncarti, 1994*)
6. Posting team actions, metrics, concepts and data around the team meeting room during the event (*Foreman and Vargas, 1999*)
7. Kaizen event team gives daily updates to management, where managers hear the team's plans and give input (*Foreman and Vargas, 1999; Boyer, 2002*)
8. Post goals and methodologies beforehand (*Mika, 2002*)
9. Use of Kaizen newspaper each day of the event to communicate tasks with team members (*Vitalo et al., 2003*)
10. Update Kaizen event documentation at each step (*Vitalo et al., 2003*)

d. Participation
1. Involving everyone on the Kaizen event team in the solution process (*Vasilash, 1993*)
2. Making each team member responsible for implementing at least one improvement idea (*Bicheno, 2001; Ortiz, 2006; Boyer, 2002; Palmer, 2001*)
3. Each team member participates in report-out to management (*Adams et al., 1997; Larson, 1998b; Mika, 2002; Adamson and Kwolek, 2008*)

V. **Broader Context** (Kaizen Event Program Characteristics)
  a. Selection of Kaizen Events
      1. Analyze whether to conduct the Kaizen event beforehand (*Vitalo et al., 2003; Maurer, 2005*)
      2. Targeted at areas that can provide a "big win" – i.e., provide a big impact on the organization (*Minton, 1998; Cuscela, 1998; Martin, 2004; Sheridan, 1997; "Keys to Success," 1997; Bradley and Willett, 2004; Melnyk et al., 1998; Tanner and Roncarti, 1994; David, 2003; Cork, 2004; Loyd et al., 2009*)
      3. Attack "low hanging fruit" (*Smith, 2003; Bicheno, 2001; Heard, 1997; Clark, 2004; Martin, 2007; Blake and Eash, 2003*)
      4. First Kaizen event targeted at highest volume, most important product (*Larson, 1998a*)
      5. Can be held based on employee suggestions for improvement (*Jusko, 2004; Watson, 2002; Heard, 1997*)
      6. Can be held based on an assessment of the critical processes of the targeted work area (*Montabon et al., 1997*)
      7. Can be held based on areas of concern in value stream maps (VSM) (*David, 2003; Tatikonda, 2008; Martin and Osterling, 2007*)
      8. Next Kaizen event can be held to address the output of a previous Kaizen event (*Adams et al., 1997*)
      9. Can be used in non-manufacturing areas – e.g., office Kaizen events (*Womack and Jones, 1996; Sheridan, 1997; Bradley and Willett, 2004; Melnyk et al., 1998; Klaus, 1998; Baker, 2005; Clark, 2004; Foreman and Vargas, 1999; Martin, 2007; Montabon, 2005; Huls, 2005; Cveykus and Carter, 2006; Dickerson and Turner, 1999; Montabon et al., 1997; Richerson, 1999*)
      10. Use of shorter, informal or "mini" Kaizen events (*Tanner and Roncarti, 1994; "Waste Reduction Program Slims Fleetwood Down," 2000; Vasilash, 2000; Martin et al., 2009*)
      11. Use of Kaizen events with other improvement approaches (*Bicheno, 2001; Cveykus and Carter, 2006*)
  b. Scheduling and Frequency of Kaizen Events
      1. Schedule Kaizen events regularly (*Huls, 2005; Destefani, 2005; Montabon et al., 1997; "Business Stationary Completes First Lean Kaizen Event," 2009; Blanchard, 2009; Radnor and Walley, 2009*)
      2. Using Kaizen events sparingly, as method of achieving breakthrough change and overturning current paradigms (*Sheridan, 2000a*)
      3. Spacing out events – e.g., only one event per quarter (*Taninecz, 1997; Ortiz, 2006*)
      4. Schedule Kaizen events at the same time every month (Ortiz, 2006)
      5. Schedule Kaizen events at least one month in advance (Venables, 2005)
  c. Sequencing and Synchronizing Kaizen Events
      1. Repeat Kaizen events in a given work area (*"Winning with Kaizen," 2002; Purdum, 2004; Womack and Jones, 1996; McNichols et al., 1999; Sheridan, 1997; Bradley and Willett, 2004; Bicheno, 2001; Adams et al., 1997; Melnyk et al., 1998; Ortiz, 2006*)
      2. Using Kaizen events across different areas of the organization or value stream (*Heard, 1997; Destefani, 2005; Lewis, 2007; Loyd et al., 2009; Marin-Garcia et al., 2009*)
      3. Using a sequence of related Kaizen events – e.g., 5S, SMED, Standard Work – to progressively improvement a given work area (*Bicheno, 2001; Melnyk et al., 1998; Laraia, 1998; Treece, 1993; Mika, 2002; Johnson et al., 2007; Langer, 2007; Loyd et al., 2009*)
      4. Concurrent Kaizen events (*Vasilash, 1997; Watson, 2002; Cuscela, 1998; Bradley and Willett, 2004; Adams et al., 1997; Wittenberg, 1994; Tanner and Roncarti, 1994; David, 2003; Johnson et al., 2007*)
          i.   Concurrent Kaizen event teams brief each other two times each event day (*David, 2003*)
          ii.   Concurrent Kaizen event teams are co-located – i.e., share the same meeting room (*Tanner and Roncarti, 1994*)
          iii. Concurrent Kaizen events use daily team leader meetings (*Wittenberg, 1994;*

Sabatini, 2000; Tanner and Roncarti, 1994)

- d. Broader Reasons for Kaizen Event Deployment
    1. Internal
        i. Using Kaizen events to train upper management on lean (*Koenigsaecker, 2005)*
        ii. Using Kaizen events to train upper management and key employees on the Kaizen event process as future Kaizen event facilitators (*Baker, 2003; White, 2000)*
        iii. Using Kaizen events to train work area mangement on Kaizen events before completing a Kaizen event in their own work area (*Montabon et al., 1997)*
        iv. Using Kaizen events to empower employees or boost morale (*Palmer, 2001; Gaboury, 2007; Dentz et al., 2009; Nahmens, 2009)*
        v. Using Kaizen events to improve communication between management and workers (*Dentz et al., 2009)*
    2. External
        i. Conducting Kaizen events specifically between suppliers and customers (*Dickerson and Turner, 1999; Rumpza, 2009; Marin-Garcia et al., 2009)*
        ii. Holding Kaizen events at supplier location (*Proctor, 1999)*
        iii. Using Kaizen events to prevent outsourcing (*Langer, 2007; Lanigan, 2004)*
- e. Kaizen Event Sustainability Practices
    1. Follow-up actions
        i. Emphasis on follow-up – e.g., consultants stayed on for 5 –10 days after the event to help standardize achievements (*Kumar and Harms, 2004; David, 2003*)
        ii. Documentation of improvements and/or action items after the event (*Martin et al., 2009; Marin-Garcia et al., 2009)*
        iii. Assigning open action items to team members for follow-up scheduling and action plans (*"Business Stationary Completes First Lean Kaizen Event," 2009; Montabon, 2005; Ortiz, 2006; Mika, 2002)*
        iv. Offline training in new processes for employees not trained during the event – i.e., second shift, etc. (*Heard, 1997; Martin and Osterling, 2007*)
        v. Clearly identifying job boundaries in updated work area standard operating procedures after event to reflect changes (*Patil, 2003)*
        vi. Follow-up Kaizen events with "traditional" kaizen (CPI) activities (*David, 2003*)
    2. Mechanisms to review the post-event progress of an event (*Patil, 2003; Doolen et al., 2008)*
        i. 30 days sustainability reviews for Kaizen events (*Heard, 1997; Montabon, 2005; Ortiz, 2006)*
        ii. Regular follow-up meetings held after the event to track open action items (*Foreman and Vargas, 19991, Palmer, 2001; Martin and Osterling, 2007*)
        iii. 30, 60, and 90 day follow-up reports to management (*Goldacker, 2005)*
        iv. Displaying metrics, charts, etc. in work area (*Magdum and Whitman, 2007; Bateman, 2005)*
        v. Use of audits and auditing tools (e.g., sustainability scorecard, audit reporting tools) (*Magdum and Whitman, 2007; Martin and Osterling, 2007; Glover et al., 2008)*
        vi. Providing support for employees to complete action items after an event (*Patil, 2003)*
    3. Organizational-wide use of Kaizen events positively influences Kaizen event outcome sustainability (*Adamson and Kwolek, 2008)*
    4. Management and work area employee skills (e.g., leadership and decision-making skills) positively influence Kaizen event outcome sustainability (*Adamson and Kwolek, 2008; Radnor and Walley, 2009; Burch, 2008)*
    5. Employee turnover negatively influences Kaizen event outcome sustainability (*Bateman, 2005; Glover et al., 2008)*

f. Kaizen Program Support
    1. Use of a "Kaizen office," including full-time coordinators/facilitators *(Heard, 1997; "Keys to Success," 1997; Bicheno, 2001; Foreman and Vargas, 1999; Martin et al., 2009)*
    2. Keeping a central database of employee Kaizen event participation, past Kaizen event results, ideas for future Kaizen events, training materials, etc. (*Heard, 1997*)
    3. Use of internal lean manufacturing experts throughout organization to share knowledge and best practices (*Destefani, 2005; Dentz et al., 2009; Loyd et al., 2009*)
    4. Regular meeting of higher management to discuss lean initiatives, including Kaizen events (*Destefani, 2005; Doolen et al., 2008*)
    5. Use of a consultant to get the Kaizen event program started – i.e., to help set up the Kaizen event promotion office, etc. (*Heard, 1997; Martin, 2004; White, 2000*)
    6. Involving virtually all work area employees as participants in some phase of the Kaizen event process (e.g., planning, implementation, etc.) (*Lewis, 2007; Martin and Osterling, 2007*)
g. Organizational Policies, Procedures, and Culture
    1. Total alignment of organizational procedures and policies with Kaizen event program (*"Keys to Success," 1997; Tanner and Roncarti, 1994; Vitalo et al., 2003*)
        i. e.g., "no layoffs" policy (*Redding, 1996; Vasilash, 1997; Creswell, 2001; "Winning with Kaizen," 2002; Womack and Jones, 1996; "Keys to Success," 1997; Bradley and Willett, 2004; Melnyk et al., 1998; Larson, 1998a; Treece, 1993; Tanner and Roncarti, 1994; "Waste Reduction Program Slims Fleetwood Down," 2000; Martin, 2007; Mika, 2002; Koenigsaecker, 2005; Montabon et al., 1997; Patil, 2003*)
    2. Organization-wide commitment to change (*Redding, 1996; Bateman, 2005*)
    3. Organization-wide communication of the philosophies behind and importance of Kaizen events (*Kumar and Harms, 2004; Montabon, 2005*)
    4. Kaizen events positively influence organizational culture (*Boyer, 2002; Drickhamer, 2004a; Goldacker, 2005; Montabon et al., 1997; Vasilash, 2000; Drickhamer, 2004a; Adamson and Kwolek, 2008*)
    5. The culture of an organization positively influences Kaizen event outcome sustainability (*Bateman, 2005*)

2.3 Summary of Phase One of OSU-VT Research: Critical Factors of Initial Kaizen Event Success

Through a review of Kaizen event, project, and team literature, the first phase of the OSU-VT research defined Kaizen event effectiveness as a function of the input, process, and outcome variables presented in Figure 4 (Farris, 2006; Farris et al., 2009). The structure of the research model for this study was informed by the team effectiveness theory models (e.g., Cohen and Bailey, 1997). Variables were operationalized and the resultant perceptual and objective data were collected from 51 events across six organizations. Kaizen event effectiveness to achieve initial outcomes was explained through the identification of direct predictors using multiple and logistic regression and indirect predictors using mediation analysis.

Kaizen Event Design Antecedents
Goal Clarity
Goal Difficulty
Team Functional Heterogeneity
Team Kaizen Experience
Team Leader Experience

Organizational and Work Area Antecedents
Event Planning Process
Management Support
Work Area Routineness

Kaizen Event Process Factors
Action Orientation
Affective Commitment to Change
Internal Processes
Tool Appropriateness
Tool Quality

Kaizen Event Outcomes
Technical System Outcomes
Goal Achievement
Impact on Area
Overall Perceived Success

Social System Outcomes
Attitude
Kaizen Capabilities

Figure 4. Kaizen Event Effectiveness Operational Research Model (adapted from Farris et al., 2009)

2.3.1 Kaizen Event Outcomes

The first phase of the OSU-VT research (Farris, 2006) studied the T0 technical outcomes, *goal achievement* and *impact on area.* Similarly, the present research studies the sustainability of the T0 technical outcomes, namely *result sustainability*, *goal sustainability*, and *impact on area sustainability*. The social system outcome for the present research is similar to the social outcomes *attitude* defined in the first phase of the OSU-VT research, but is oriented to capture its value with respect to the work area employees and management, as opposed to the Kaizen event team. This approach allows the researcher to study the potential influence of the Kaizen event on the attitudes of individuals in the work area after the Kaizen event.

2.3.2 Kaizen Event Initial Critical Factors

The research findings from the first phase of the OSU-VT research are summarized in Table 4 (Farris, 2006). The critical input and process factors are identified in Table 4 and are either positively (+) or negatively (-) related to the initial outcomes. For example, *attitude* is positively related to *management support* and negatively related to *team functional heterogeneity*. *Management support* and *team functional heterogeneity* are both drivers of *attitude*. The present research includes the T0 variables *goal clarity, goal difficulty, team functional heterogeneity, work area routineness,* and *management support* as Kaizen Event Characteristics to determine whether or not they are also drivers for sustaining outcomes.

Table 4. Summary of the Drivers of Outcome Variables (adapted from Farris, 2006)

Kaizen Event Outcome Drivers	Outcomes			
	Attitude	Kaizen Capabilities	Goal Achievement	Impact on Area
Management Support	+			+
Goal Difficulty		+	-	-
Team Autonomy		+		+
Goal Clarity	+	+		
Internal Processes	+	+		
Work Area Routineness		+		+
Team Kaizen Experience		-	-	
Team Leader Experience		-	-	
Action Orientation			-	+
Functional Heterogeneity	-			
Affective Commitment to Change		+		
Tool Quality				

Event Planning Process			+	
Tool Appropriateness				

2.4 Kaizen Event Sustainability Literature

A major obstacle for many organizations is to actually sustain or improve the results of a Kaizen event after it concludes (Friedli, 1999; Mackle, 2000; Cork, 2004). The following presents the Kaizen event and lean practitioner resources that relate to Kaizen event sustainability and then presents the Kaizen event academic literature that relates to Kaizen event sustainability.

The practitioner's guide written by Laraia et al. (1999) suggests some companies may find it difficult to sustain even 50% of initial outcomes. Kaizen event practitioner resources, identified as Trade Press, Case Studies, or Expert Kaizen Event Methodologies in Section 2.1, are somewhat limited in their discussion of sustainability because many resources discuss the progression of a single Kaizen event during the event time frame and do not discuss the activities that occur in the targeted work area after the Kaizen event. However, some Kaizen event practitioner resources do discuss the sustainability of outcomes and propose event outcome sustainability activities. Furthermore, there are expert practitioner resources that discuss techniques to sustain lean improvements. While these resources do not focus solely on Kaizen events, they do emphasize practices that relate to the present study of Kaizen event sustainability. The techniques from these practitioner resources are grouped according to three categories in

Table 5: *improvement culture, institutionalizing change*, and *performance review* as defined in Chapter 1. These categories were created, inductively, from the literature by the larger research team and are referred to as Post-Event Characteristics throughout this research.

Table 5. Post-Event Characteristic Activities Found in Practitioner Literature

Post-Event Characteristic	Example Activity	Author(s) Citing the Activity
Improvement Culture	Management support of Kaizen events by allocating the necessary resources (e.g., human resources, equipment, and information) at all stages of a Kaizen event program (initial execution to performance maintenance and continued improvement)	Heard, 1997
	Support of continuous improvement as a part of organizational culture	Cuscela, 1998

	Work area management supporting the use of Kaizen events in the work area	Tonkin, 2008
	Providing support for employees to complete action items after the event	Palmer, 2001
Institutionalizing Change	Training employees in new work methods	Heard, 1997; Goldacker, 2005
	Incorporating changes into standard work definitions and methods of the targeted work area via work area documentation	Heard, 1997; Mann, 2005; Powell and Hoekzema, 2008
Performance Review	Use and review of performance data related to Kaizen event goals	Martin and Osterling, 2007; Adamson and Kwolek, 2008;
	Audits and auditing reporting tools	Martin and Osterling, 2007; Powell and Hoekzema, 2008
	Follow-up meetings with kaizen event team	Martin and Osterling, 2007; Palmer, 2001
	Regular follow-up reports/meetings to management	Goldacker, 2005

Additionally, practitioner resources describe work area characteristics related to learning behaviors that may also impact the sustainability of Kaizen event outcomes such as sharing lessons learned with all other work area and process employees (Mika, 2002; Vitalo et al., 2003) and continuous employee development (Drickhamer, 2004a). Sources suggest that Kaizen event initiatives must be considered as a "way of life," not an initiative, in order to prevent them from being viewed as something that will eventually end (Cork, 2004; Flint, 2007). Work area managers are encouraged to identify, participate in, or lead improvement activities in their work areas (Mann, 2005). Furthermore, communication across work areas may support continued improvement after a Kaizen event by assisting team members and work area employees in understanding the interaction between work area processes and adjacent or related processes (Tennessen and Tonkin, 2008).

There are a few scholarly works that also provide support for concepts that are included in the present research. As a way to describe a part of the Kaizen event assessment methodology used throughout the OSU-VT research, Doolen et al. (2008) conducted a case study of two Kaizen events within a single organization. The study evaluated the initial success of the Kaizen events as well as the sustainability of technical and social system outcomes approximately nine months after each event. The key findings of the case study that relate to kaizen event sustainability were as follows:

- Even within a single organization, Kaizen events may have varied long-term success with respect to business and human resource-related effects on the targeted work area

- Positive attitudes at the conclusion of a successful event did not automatically translate to sustained performance improvement or employee enthusiasm

- Follow-up activities (e.g., use of performance measures and reporting performance measures to higher-level management quarterly) appear to be important to the sustainability of performance over time

- Management support was found to be related to initial human resource outcomes and may also be important to the sustainability of outcomes because of the important role management may have in the support of follow-up activities

Veech (2004) presents a conceptual model that suggests employee self-efficacy, supported by various factors, is needed to sustain lean systems. It should be noted that the research does not provide testing of the model and limited literature is presented to support the model. While the research does not specifically address Kaizen events, but rather lean systems in general, the author does anecdotally report that Kaizen event improvements may disappear within six months of an event. In order to support employee self-efficacy and therefore, prevent deterioration of lean improvements, the following concepts are emphasized:

- Contributors to employee self-efficacy include skill mastery, learning behaviors, coaching (as opposed to directive supervision) and motivation

- Employee job satisfaction by emphasizing job meaningfulness, awareness, and responsibility among employees may also support employee self-efficacy

- Standard work may strengthen an employee's sense of control of the environment and further enhance employee self-efficacy

Patil (2003) conducted a field study of one Kaizen event in a manufacturing organization to determine whether outcomes were sustained eight months after the event. Through a sustainability checklist and audit of the area by Patil and the event leadership, Patil found a lack of sustainability and created a framework for sustaining Kaizen events based on the shortcomings of the event studied. The suggestions made in this study for sustaining Kaizen event results were:

- Having an internal communication network for sharing training and performance information
- Ensuring job security
- Identifying employee needs, including understanding employee psychological, financial, and safety-related needs
- Involving employees in event planning and decision making
- Providing support for employees to complete action items after event

- Using mechanisms to review the post-event progress of Kaizen event teams
- Training employees in the benefits of Kaizen
- Training employees in Kaizen event process management
- Using standard operating procedures (SOPs), based on event changes
- Emphasizing a clear link between organizational strategy and Kaizen events
- Developing a cross functional team
- Identifying job boundaries in SOPs

In the case study of a manufacturing company, Magdum and Whitman (2007) observed several practices and characteristics that made the case organization successful at outcome sustainability such as the use of a Kaizen newspaper/30-day action item list, displaying metrics, charts, etc. in the work area, using 5S, and the use of audits and sustainability scorecards. Magdum and Whitman (2007) suggested that the company's sustainability of improvements could be improved by the adoption of adequate metrics to measure the sustainability of all Kaizen event types, the improved display of charts, the use of both social and technical outcomes, the use of periodic team meetings, and the communication of Kaizen event results to the entire organization.

Miller (2005) studied the structure of motivational influences within a Kaizen event. Although Miller (2004) did not specifically address Kaizen event sustainability, he and other researchers (e.g., Upton, 1996) have suggested that motivation may be important to the sustainability of improvement-related behaviors. The study collected data from 166 employees from four organizations utilizing Kaizen events through questionnaires. The data were analyzed through structural equation modeling. This study suggests that two factors may increase positive

achievement behaviors (team member persistence, effort, choosing to participate, and performance at activity), and thus increase motivation. The two factors are:

(1) improving "expectancy" (or expectation for success at activity and the perception of one's ability to complete activity) and

(2) improving task value beliefs (importance, usefulness, and interest/enjoyment) of the participants in a kaizen event.

Thus, elements such as day-one training, management support, celebration of success, and documentation of improvements anecdotally appear to positively influence perceptions of confidence and beliefs that the problem solving interventions utilized within Kaizen events are important and useful (Miller, 2004). The study also found that the interest/enjoyment beliefs of the participants of Kaizen events most strongly influenced the positive achievement behaviors that may lead to motivation for lasting change.

Marin-Garcia et al. (2009) studied the sustainability of a set of Kaizen event technical system measures (quality, overall equipment efficiency, dock to dock time, workforce productivity, and changeover time) across eleven Spanish automotive component companies over a nine to twelve month period. Two to three Kaizen events were studied in each organization. On average, the organizations experienced improvements in quality, overall equipment efficiency, and workforce productivity and decreased performance with respect to dock to dock time and changeover time. A noted limitation of the research was the difficulty in gathering data. In some cases, the researchers noted inconsistently reported data that came from different sources. In order to gather accurate data, the researchers spent up to two days on-site with the assistance of work area managers and external consultants that facilitated the Kaizen events. The research did not focus on the variables that may explain sustainability, but did note that the training before the Kaizen event, the facilitation provided by the external consultants, the documentation of action items after the event, and management support were observed to support the sustainability of Kaizen events.

Burch (2008) examined individual and organizational factors that contribute to the individual and organizational success and sustainability of kaizen event outcomes using correlation analysis and qualitative methods. The study hypothesized that the organizational level independent variables, *facilitator's level of expertise, number of previous Kaizen events, layoffs,* the employee involvement variables, *participation in decision making* during the Kaizen

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event, *communication* about the Kaizen event, *and training* during the Kaizen event, and the attitudinal variables, *trust, job security, and respect for top management,* were correlated with the outcome variables. Two organizational outcome variables, *performance gains* and *sustainability,* were defined according to a five-point scale (1= "complete success or sustainability" to 5= "performance worse than initial state before the Kaizen event"). The scale value for *performance gains* and *sustainability* was determined by the researcher through information from interviews and observations. The perceptual outcomes *climate of continuous improvement, perception of goal achievement, motivation to continuously improve, job satisfaction,* and *commitment* were collected from the Kaizen event team and work area employees.

Burch's (2008) research design included three stages:

(1) In-depth interviews regarding Kaizen events were conducted with management from two organizations to inform the development of a survey instrument used in the second stage

(2) Two questionnaires were administered to study 13 Kaizen events across eleven organizations. One questionnaire was administered to the Kaizen event team members and a slightly different questionnaire was administered to the work area employees from the targeted work areas of the Kaizen events that were not on the Kaizen event team. Correlation analysis was used to examine the relationships between the independent and attitudinal variables and the dependent variables. Interviews were also conducted with the facilitators and work area management of each Kaizen event to assist in explaining the quantitative findings.

(3) Follow-up interviews with managers and employees were carried out at the participating organizations three to six months after completion of the Kaizen event to assess the sustainability of the Kaizen events.

The correlation analysis identified the weak (correlation coefficient less than 0.4), moderate (correlation coefficient between 0.4 and 0.7), and strong (correlation coefficient greater than 0.7) relationships between the potentially related factors and the outcomes. In general, the correlation analysis found that Kaizen event team member perceptions of the potentially related factors were either weakly or not correlated to the outcome variables (Burch, 2008). The relationships between the work area employee perceptions and the outcomes studied that were found to be moderately to strongly significant (at $\alpha \leq 0.05$ level) are highlighted in Table 6.

Relationships that were not significant are labeled "N.S." and relationships that were not tested in the research are labeled "N.T."

Table 6. Summary of Correlation Analysis Between Work Area Employee Perceptions and Outcome Variables Found in Burch (2008)

	Outcomes					
	Performance Gains	Sustainability	Climate Of Continuous Improvement	Employee Perceptions Of Goal Achievement	Organizational Commitment	Motivation To Continuously Improve
Participation In Decision-Making	Strong	Strong	Strong	Weak	Weak	N.S.
Communication	Strong	Strong	Strong	Moderate	Moderate	Moderate
Trust	N.T.	N.T.	Moderate	Moderate	N.T.	Moderate
Respect For Top Management	N.T.	N.T.	Moderate	Moderate	N.T.	Weak
Job Security	N.T.	N.T.	Weak	Moderate	N.T.	Weak

For the outcome, *sustainability*, one of the eleven (9%) work areas studied sustained all changes as a result of the Kaizen event, six of the eleven (55%) sustained most changes, one of the eleven (9%) sustained some changes, two of the eleven (18%) did not sustain changes, and one of the eleven (9%) experienced a decline in performance, resulting in performance that was worse than its initial state before the Kaizen event. Qualitative findings from the research found that management reported between 30% and 50% Kaizen event improvements were not sustained. When asked to report the factor that would have increased the likelihood of Kaizen event improvement sustainability, the most frequent response was follow-up audits.

The most extensive empirical studies to date, related to sustaining Kaizen event outcomes, were led by Nicola Bateman who studied 40 Kaizen events that occurred in 21 companies (Bateman and David, 2002; Bateman and Rich, 2003; Bateman, 2005). The work of Bateman and David (2002) defined a model for assessing the sustainability of Kaizen events that was used to guide subsequent studies (Bateman and Rich, 2003; Bateman, 2005). In short, the work area level sustainability assessment criteria included three key questions:

- Are all actions on the problem follow-up list closed out?

- Did the operators and setters maintain the new method of working outlined in the workshop (i.e., Kaizen event)?
- Has the team continued to meet and tackled new problems in the cell area?

The factory level sustainability assessment criteria included two key questions:

- Has the company replicated the improvement made to any other areas?
- Has the company applied improvement tools to any other area?

The work of Bateman and Rich (2003) used qualitative research methods to assess perceptions regarding factory level and work area level "enablers" and "inhibitors" based upon the views of informants undergoing the process improvement intervention. Interviewed informants included the "change champion," or senior manager responsible for the factory's process improvement program, the event facilitators, and the manager of the targeted production area. Team leaders and operators in the targeted production area were also interviewed to triangulate the research findings. Interestingly, respondents were able to easily identify specific inhibitors, but found it difficult to identify specific enablers. Instead, the enablers were of a more general and cultural nature which may indicate managers may not know how to affect cultural change. The enablers that were associated with successful and sustainable process improvement programs were:

- Availability of financial and non-financial (e.g., human) resources
- General culture, including having an open minded culture and an enthusiastic workforce
- The need to change/improve
- Strong event champions
- Effective communication, including use of communication to promote/clarify need for change
- Manager's approach, including proactive practices to support change and counteract potential barriers to improvement
- Strong team leaders

The inhibitors of sustainability identified by Bateman and Rich (2003) were:

- Lack of non-financial resources, including access to production equipment and human resources
- A 'low' need to change
- Lack of management support

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- Inappropriate measurement system, including the use of measures that may inhibit the behaviors needed to support a PI program

- High employee turnover

- Lack of process improvement focus

- Lack of financial resources

Bateman (2005) compiled an extensive list of enablers and inhibitors through consultation with expert engineers and academics in the field and conducted structured interviews with 40 event participants across 21 organizations. Bateman's research determines improvement sustainability at the work area level via four key characteristics: 1) achieve improvement during the workshop, 2) maintain the new procedures, 3) close out any technical issues, and 4) achieve continuous improvement beyond the performance levels acquired during the Kaizen event by dealing with new issues in the work area and improving the work area on a regular (e.g., weekly) basis (Bateman, 2005). The results of companies that possessed all 4 characteristics (labeled "A"s) were compared against the results of companies that did not possess all 4 characteristics using the chi-square test to identify those factors that characterized an A-labeled company. Because many of the reported enablers were the opposite of the inhibitors, the final recommendations of this research were presented as a list of general sustainability enablers; those enablers were as follows:

- Following the Plan-Do-Check-Act cycle in closing out actions, including making time for 5S activities, formally recording ideas, actively using work area performance measurements to monitor improvements, formally introducing work area employees to new work methods, and work area managers staying focused on PDCA activities

- Enabling processes for continuous improvement by ensuring work area employees can make collective decisions with one another regarding the way that they work, actively using work area performance measurements to monitor improvements, and having a defined direction and goals for the work area

- Using organizational strategy and a supportive management structure by having a defined direction and goals for the work area, having a person that coordinates process improvement activities across the organization, and having senior management focused and involved in performance improvement activities

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The common themes found in the Kaizen event sustainability practitioner and scholarly literature informed the creation of the questionnaire presented in the Research Methods section (Chapter 3).

2.5 Continuous and Process Improvement Sustainability Literature

Because there is limited research on Kaizen event sustainability, this section reviews publications that discuss sustainability with respect to different process and continuous improvement methods. Table 7 summarizes the common findings from these studies that related to Post-Event Characteristics and Work Area Characteristics. These characteristics may also influence outcome sustainability after Kaizen events and, thus, should be examined to inform Kaizen event sustainability research. Table 7 also includes a "Process Improvement Characteristics" category to capture the findings that are specific to the process improvement approach used and an "Other" category that captures factors that may impact sustainability but are outside of the scope of this research.

To address the sustainability of continuous improvement, Kaye and Anderson (1999) reviewed relevant literature and conducted semi-structured interviews. Their research resulted in a model that highlights the ten essential criteria of continuous improvement. Upton (1996, p. 17) claimed that "sustainability, continuous improvement over time, depends upon the underlying view of how improvement is achieved implicit in the actions of both managers and operators." Upton's continuous improvement initiatives model focuses on accelerating performance improvement, maintaining consistent long–term objectives, and choosing periodic projects based on organizational ability. These focus areas appear to provide direct improvement in the chosen direction and provide a platform for future gains. More recently, Readman and Bessant (2007) assessed the results of the United Kingdom's (UK) Continuous Improvement Survey that was administered to 1000 UK firms. A part of the survey inquired about enabling improvement activities that served to encourage or reinforce the continuous improvement behaviors and routines. The most frequently reported enabling activities that assisted in the facilitation of continuous improvement were identified (Table 7). Anand et al. (2009) identified infrastructure decision areas that are important for continuous improvement initiatives through the creation of a framework of continuous improvement as a dynamic capability when it includes a comprehensive organizational context. A dynamic capability can be defined as a "learned and

stable pattern of collective activity through which the organization systematically generates and modifies its operating routines in pursuit of improved effectiveness" (Zollo and Winter, 2002, p. 340). The framework was used to investigate continuous improvement initiatives in five case study companies.

To address the sustainability of various process improvement activities, Dale, Boaden, Wilcox, and McQuater (1997) identified key TQM sustainability issues through qualitative research and reference to relevant theoretical literature. Keating et al. (1999) worked with research partners to address general process improvement program sustainability. System dynamics modeling analysis explained both internal dynamics and external interactions that appear to influence the sustainability of process improvement activities. Oxtoby et al. (2002) also address general process improvement program sustainability and used qualitative research methods to identify 15 key factors that determine an enterprise's change capability. Pillet and Maire (2008) surveyed 40 organizations to examine their performance across different types of improvement activities (e.g., 5S, ISO9000, etc.) and to understand the factors that they viewed as most important for sustainability. Across multiple process improvement activities, organizations sustained, on average, 40 percent of improvements, which further illustrates the difficulty that organizations have in sustaining improvements. Based on the survey results, the authors created a model of process improvement sustainability that was based on three "axes": organic state (the state towards which the organization will trend with no effort and absence of constraints), return on effort (reinforcing activities to encourage desired improvement activities), and facilitation (developing skills, group synergy, and simplified processes to support the desired improvement activities) (Pillet and Maire, 2008).

Many of these studies emphasize the following characteristics or activities in order to sustain improvement outcomes over time: communication within the work area and across various levels of the organization (top-down, bottom-up, and lateral communication), work area employee focus and commitment, improvement activity characteristics (e.g., project scope, goals, and improvement team dynamics), improvement culture, learning (education and training), management, measurement, and organizational structure and policies. Less commonly-noted sustainability characteristics are the impact of the external environment, external stakeholders, and team characteristics. As with the Kaizen event sustainability literature, the common themes

found in the process and continuous improvement literature informed the creation of the Post-Event Characteristics presented in the Research Methods section (Chapter 3).

Table 7. Summary of Outcome Sustainability Characteristics Identified in Scholarly PI and CI Literature

Theme	Dale et al., 1997	Kaye and Anderson, 1999	Keating et al., 1999	Oxtoby et al., 2002	Upton, 1996	Readman and Bessant, 2007	Pillet and Maire, 2008	Anand et al., 2009
Improvement Culture	• Leadership seeking continuous improvements to the system	• Establishing a culture for continuous improvement • Senior management commitment and involvement • Leadership and active commitment to continuous improvement demonstrated by managers at all levels	• Freeing employees to improve processes	• Establish leadership (e.g., sustainability champion) • Reward and recognition systems	• Leader to provide compelling motivation for improvement	• Support from top leadership and managerial staff	• Involvement of top management and supervisory staff	
Institutionalizing Change	• Establishing procedures to counteract problems and abnormalities and having employees understand and follow those procedures	• Encouraging high involvement	• Training in improvement approaches	• Involve all employees • Develop materials to help helping people to learn how to implement new changes	• Education and training in new work methods and processes • Structures to prevent backsliding		• Involvement of employees	
Performance Review		• Establishing measurement and feedback systems		• Measure against goals (e.g., constant audits)	• Structures to prevent backsliding	• Monitoring the improvement activities	• Regular and frequent follow-up activities	• Standardized processes, including enabling measurement and comparison for improvement projects
Work Area Characteristics	• Training, coaching and development of employees (i.e. skills,	• Awareness of CI by employees • Encouraging	• Employees understand the benefits of and commit to	• Involve all employees • Create commitment	• Knowledge development and capture (e.g., active experimentat	•	•	• Culture of constant change (e.g. preparing employees

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	attitudes and behaviors)	• high involvement and innovation • Learning from continuous improvement results • The automatic capturing and sharing of learning • Employee focus	improvement independent of management • Employee perceptions of effectiveness of improvement effort	among all involved	ion)			for constant change) • Creating a participative climate • Knowledge management and training when appropriate
Process Improvement Characteristics	• Teams and teamwork • Adequacy of improvement infrastructure (e.g., facilitator capabilities)	• Focus on critical processes across boundaries and at all levels.	• Project complexity • Scope and adequacy of the chosen improvement methodology	• Clear goals • Implement improvements • Arrange time, space, etc.	• Focused team initiatives • Clear goals • Consistent focus of improvement	• Work in teams or work groups	• Well structured and organized implementation of improvement • Simple, irreversible, and/or rapid improvement	• Formulation and communication of organizational and project goals • Standardized improvement method
Other	• Planned approach to identify, apply, and integrate improvement tools and techniques into daily operations • Management style and confidence in senior management • External environment (e.g., competitors) and internal environment (e.g., customer focus) issues	• Stakeholder focus • Integrating continuous improvement activities into the strategic goals across the whole organization • Systematic documentation of best practices	• Interactions with other initiatives (e.g., other initiatives in same work area) • Interactions with other Organizational Units • Interactions with the Market (extreme demand increase) • Job Security	• Compelling business need • Discover preferred learning methods • Record and incorporate best practices • Visible display of progress	• Management reorganization • External comparison • Selecting projects based on ability to improve a specific target and ability to provide future improvement opportunities	• Face-to-face communication • Training of personnel in problem solving tools • Regular shop floor visits by management	• Visible and practical results • External consultant • Implementation of improvement is integrated with other actions in progress	• Balanced innovation and improvement • Parallel participation structures (e.g., cross-functional cooperation) • Information technology support

	• Organizational structure and organizational policies that may conflict with improvement activities						

2.6 Organizational Change Literature

The term *institutionalization* is used frequently in organizational change literature to describe the integration of a change into the usual activities of an organization (Johnson et al., 2004). An institutionalized act is formally defined by its persistence, performance by multiple others, and its existence as a social fact in an organization (Goodman et al., 1980). Organizational change literature suggests that the implementation of new programs or behavior often achieves some initial success but that high degrees of change institutionalization are generally difficult to achieve (Goodman and Dean, 1982); i.e., "lasting change is usually the exception rather than the rule" (Buller and McEvoy, 1989, p. 36-37). Thus, difficulty maintaining outcomes is not unique to Kaizen events.

The Kaizen event, process improvement, and continuous improvement sources reviewed identify Kaizen event characteristics and practices that may impact the maintenance of Kaizen event outcomes but do not provide a framework to describe how the characteristics and practices may be related. Models of change institutionalization from organizational change theory are presented here in order to inform the modeling of Kaizen event outcome sustainability. The change programs referred to in the institutionalization research were ongoing (e.g., used regularly and across the organization). Similarly, the present research sampled organizations that used Kaizen events programmatically, as opposed to on an ad-hoc basis. For example, an organization had to conduct Kaizen events relatively frequently, i.e., at least one Kaizen event per month, in order to participate in the study (full criteria described in Section 3.2). This similarity provides additional support of the use of change institutionalization to inform the study of Kaizen event outcome sustainability. While the regular use of Kaizen events has been noted in the Kaizen event body of knowledge (e.g., LeBlanc, 1999; Sheridan, 1997; Vasilash, 1997; Melnyk et al., 1998), the ad-hoc use of Kaizen events is more often presented in the practitioner resources. However, using Kaizen events in isolation may hinder outcome sustainability because the event outcomes may not be integrated into the overall strategic objectives of the organization (Radnor and Walley, 2009). Through the adaptation of change institutionalization, this research explains Kaizen event outcome sustainability within the context of programmatic Kaizen event use.

The first model by Goodman and Dean (1982) in Figure 5 shows that *organizational characteristics* and the *structure of the change* influence a set of *processes* that in turn have a

direct effect on their five *institutionalization facets*. The empirical study presented with this model collected qualitative data via interviews to describe the nine studied organizations in terms of their degrees of institutionalization (Goodman and Dean, 1982). For example, the organization with the highest degree of institutionalization of the change studied was rated by researchers as medium-high to high on four of the five *institutionalization facets*. This method is similar to the final ranking of organizations presented by Bateman (2005), where the organizations were placed into classes based on their levels of four sustainability stages — *achieve improvement during workshop, maintain the new procedures, close out any post-event action items,* and *achieve continuous improvement*.

Organizational Characteristics -social context in which the change is introduced and evolves *Existing values, norms, character or labor-management relationships, skills of the work force*	**Processes** 1. *Socialization*-transmission of information to organizational members about the requisite behaviors and learning mechanisms within individuals that affect the interpretation of information 2. *Commitment*-binding of the individual to behavioral acts 3. *Reward Allocation*-types of rewards related to the behaviors and the schedule of their distribution 4. *Diffusion*-extension and adoption of a new work behavior into a new social system 5. *Sensing and recalibration*-processes by which the organization can measure the degree of institutionalization, feed back information, and make corrective action	**Institutionalization Facets (Criteria)** 1. *Knowledge*-extent to which an individual has knowledge of a particular behavior 2. *Performance*-extent to which each behavior is performed across the participants in the social system 3. *Personal Dispositions*-extent to which the participants like (or dislike) performing the behavior) 4. *Normative Consensus*-extent to which (1) organization participants are aware of others performing the requisite behaviors and (2) there is consensus about the appropriateness of the behavior 5. *Value Consensus*-the social consensus on values relevant to the specific behaviors
Structure of the Change *Goals of the change* *Critical roles (e.g., autonomous work groups, survey feedback, team building, etc)*		

Figure 5. Model of Variables Related to Institutionalization (adapted from Goodman and Dean, 1982)

This institutionalization model is modified slightly and highlighted in the textbook *Organizational Development and Change* (Cummings and Worley, 1997). The text provides example activities for all of the stages of the framework, including the organization characteristics, intervention characteristics and the institutionalization processes. This adapted version of the framework is illustrated in Figure 6.
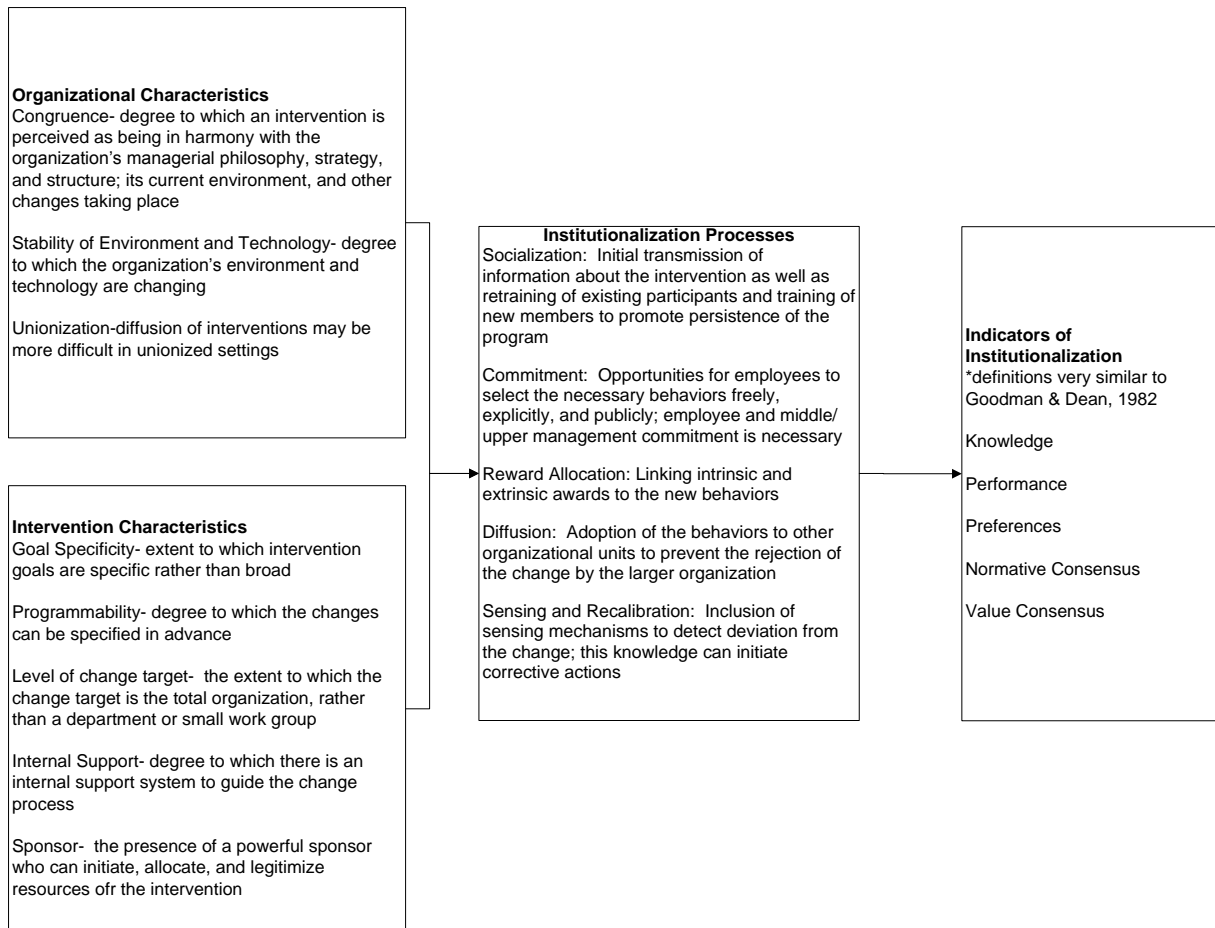
Figure 6. Institutionalization Framework (adapted from Cummings and Worley, 1997)

Buller and McEvoy (1989) also modified the Goodman and Dean (1982) model by including phases for the change process: the introduction of the change, the decision to adopt a change, the decision to continue the change characterized by the level of congruence between initial expectations of the change and actual outcomes, and finally the decision to persist with the change, or to make the change a permanent part of the organization. Also, Buller and McEvoy (1989) updated the model by making it more appropriate for their study of the adoption of a new performance appraisal system for a government organization. Because this model was only used to conduct empirical research in one organization, the organizational characteristics and structure of the change were described qualitatively. The data on the independent variables (Figure 7), institutionalization, and performance were collected via a 31-item questionnaire. The construct reliability values were reported and were greater than 0.60 for each construct except *involvement*, which was 0.34 and dropped from analysis. The stepwise multiple regression analysis found that

four variables—congruence, supporting mechanisms, top management support, and feedback—explained 47% of the variance on the institutionalization scale and five variables—group norms, supporting mechanisms, unexpected consequences, involvement, and feedback—explained 51% of the variance on the performance scale. The Buller and McEvoy model provides support for modifying the original model in order to fit the purposes of a research topic.

Independent Variables
1. *Values*: An overall perception that the change was needed and valued by employees
2. *Congruence*: The perceived congruence of the change with existing department norms and goals
3. *Supporting mechanisms*: A perception of the extent to which supporting mechanisms (e.g., training, personal ability, clear goals, trust in change sponsors) existed
4. *Unexpected consequences*: The extent to which unanticipated problems were perceived as resulting from the change
5. *Top management support*: Degree to which top management is seen as supportive of the change
6. *Feedback:* The perceived level of feedback about the effects of the change
7. *Group norms*: The perceived level of normative consensus in the immediate work group for the change
8. *Involvement*: Opportunity to be involved in making the decision to make the change

Institutionalization
Extent to which the change(a) was actually being used (b) had become a routine way of operating, and (c) would have a lasting impact in the department

Performance
Perceptions of the extent to which the change had improved overall performance (financial benefits, productivity, quality, and working climate)

Figure 7. Model of Variables Related to Institutionalization (adapted from Buller and McEvoy, 1989)

Osman-Gani and Jacobs (2004) referenced the institutionalization framework (Cummings and Worley, 1997) to model the institutionalization of human resource development interventions. It is unclear the extent to which the institutionalization framework (Cummings and Worley, 1997) directly influenced Osman-Gani and Jacobs (2004) research in terms of the research design or analysis. For instance, the questionnaire items are not provided and the results appeared to exclude concepts that were in the Cummings and Worley (1997) framework, e.g., *commitment*. However, the research does serve as another example of an empirical study that used this framework to inform the theory of institutionalization of a specific type of change.

2.7 Research Model and Literature Support

Based on the presented literature, the preliminary model of Kaizen event outcome sustainability is presented (Figure 8). The model excludes any variables from the institutionalization models that relate to individual measures because the unit of analysis for this research is the organizational unit as opposed to the individual employee. The model also excludes the variable, Diffusion, as this research is only concerned with the sustainability of a Kaizen event outcome within its work area of origin as opposed to its adoption across other work areas. This section explains the four categories of variables that are included in the model (Kaizen Event Characteristics, Work Area Characteristics, Post-Event Characteristics, and Sustainability Outcomes). For each category, an explanation regarding how the variables in the category relate to the institutionalizing change models is provided. Then, additional literature support regarding how the variables relate to previous research of the sustainability of Kaizen event or other improvement approaches is provided.

Work Area Characteristics
Work Area Routineness
External Perspective
Experimentation
Internal Collaboration
Group Stewardship
Knowledge of Continuous
Improvement
Management Kaizen Event
Participation
Workforce Changes
Production System Changes

Post-Event Characteristics
Institutionalizing Change
Improvement Culture
Performance Review

Sustainability Outcomes
Result Sustainability
Goal Sustainability
Impact on Area Sustainability
Work Area Attitude
Work Area Commitment

Kaizen Event Characteristics
Goal Clarity
Goal Difficulty
Team Functional Heterogeneity
Management Support

Figure 8. Preliminary Operational Research Model

2.7.1 Kaizen Event Characteristics

The present research identified and measured four Kaizen Event Characteristics that may impact Kaizen event outcome sustainability: *goal clarity, goal difficulty, team functional heterogeneity,* and *management support*. These factors describe the structure of the change, including the goals, strategies, tactics, and programs of change. Certain structural features of change programs have been found to impact the institutionalization of change. Specifically, previous research has found that (Goodman and Dean, 1982):

- Change programs with more specific goals have been found to exhibit higher levels of institutionalization.

- Change mechanisms that have more highly programmed structural features have been found to exhibit higher levels of institutionalization. For example, , parallel work teams have been found to have detailed, explicit documents that defined the team's design, composition, meeting time, intergroup relationships, and procedures for initiating a meeting. Autonomous work groups, on the other hand, defined their own sets of self-governing decisions. The highly programmed parallel work teams exhibited higher levels of institutionalization than the autonomous work groups with structural features that were programmed to a lesser extent.

- The presence of an internal support system has also been found to impact the institutionalization of change.

The following presents the definitions of the proposed Kaizen Event Characteristics (Farris, 2006) and also presents the relevant literature that supports the inclusion of each factor for further study.

Goal clarity is defined as the extent to which the team's objectives have been explicitly defined. Organizational change research emphasizes the importance of clear goals in order to sustain organizational change (Oxtoby et al., 2002). *Goal difficulty* describes the subjective difficulty of event objectives as perceived by team members. Process improvement literature suggests that project scope and project complexity may negatively impact sustainability of improvement (Keating et al., 1999).

Team functional heterogeneity describes the diversity of functional expertise within the Kaizen event team. Kaizen event sustainability literature suggests that the development of a cross-functional team supports the sustainability of Kaizen event outcomes (Patil, 2003).

Management support describes the support that senior leadership provided to the team, including materials and supplies, equipment, and assistance from organizational members. A lack of management support has been found to be an inhibitor of Kaizen event outcome sustainability (Bateman, 2005).

One caveat regarding the use of the institutionalization theory to model Kaizen event outcome sustainability is that the change programs referred to in the institutionalization research were change mechanisms that generally used the same program participants throughout the implementation and maintenance of the change. Sustaining changes from the Kaizen event depends upon an entity other than the Kaizen event team: the targeted work area. Therefore, certain aspects of the improvement mechanism structure (i.e., Kaizen event) may not influence outcome sustainability to the same extent as the structural characteristics of the work area. For example, interpersonal relationships of the Kaizen event team may not influence outcome sustainability to the same extent as the interpersonal relationships of the work area and its employees.

Furthermore, some Kaizen event team and process characteristics that were considered in the study of initial success (Farris, 2006), specifically *team Kaizen experience, team leader experience, team autonomy, event planning process, action orientation, internal processes, tool quality,* and *tool appropriateness* are not directly discussed as critical factors in the sustainability literature. While an indirect relationship between these factors and outcome sustainability may be inferred, these relationships may not adequately support the inclusion of these variables in the final model. For example, *team Kaizen experience* describes the average Kaizen event experience within the Kaizen event team. While the Kaizen event and organizational change literature does not directly relate team member experience to sustained outcomes, it is suggested that training employees in Kaizen events, including the training and learning that occurs during their participation during a Kaizen event, may support the sustainability of Kaizen event outcomes (Patil, 2003). In this instance, while a connection between the variable and the sustainability literature can be inferred, it is a tenuous relationship. Therefore, certain variables that are specific to the behaviors and relationships of the Kaizen event team and processes may not be appropriate in the model of Kaizen event sustainability and are not included in the current research model. However, because these factors may lead to improvement directly after the Kaizen event (T0 performance) these factors may provide a better foundation for Kaizen event

outcome sustainability (T1 performance). Therefore, the factors were considered in post-hoc analysis (see Section 4.6).

2.7.2 Work Area Characteristics

This research identified and measured six perceptual Work Area Characteristics: *knowledge of continuous improvement, external perspective, experimentation, internal collaboration, group stewardship,* and *work area routineness*. Three proposed objective work area characteristics were also measured: *management Kaizen event participation, workforce changes (*including work area employee and management turnover), and *production system changes* (including changes to work area equipment, product volume and product mix). These factors relate to organizational characteristics that have been found to impact the institutionalization of change. Specifically, organizational change research has found that the values and norms of the work area (Goodman and Dean, 1982; Cummings and Worley, 1997), the overall perception that change was needed and valued by employees (Buller and McEvoy, 1989), how the skills of the work force align with the change (Walton, 1980; Goodman and Dean, 1982; Cummings and Worley, 1997), and how the degree of stability in the organization's environment and technology may impact change sustainability (Goodman and Dean, 1982; Cummings and Worley, 1997).

The following describes each factor as supported by the relevant Kaizen event and general process improvement literature. *Knowledge of continuous improvement* is based on a measure defined in Doolen et al. (2003) and relates to the extent to which the individuals have knowledge of the continuous improvement behaviors needed to sustain the change. Research has suggested that an awareness and understanding of continuous improvement knowledge may be important to the sustainability of improvement (e.g., Kaye and Anderson, 1999). Learning behaviors, *external perspective, experimentation,* and *internal collaboration,* and *group stewardship* are based on the study of group stewardship and group learning behaviors by Groesbeck (2001). Learning behaviors are frequently cited as important to improvement sustainability (e.g., Upton, 1996; Kaye and Anderson, 1999; Burch, 2008; Anand et al., 2009). *External perspective* can be described as the extent to which work area employees think about how their work relates to that of others, including to other work areas and the overall organization (Groesbeck, 2001). Learning through *external perspective* can occur through opportunities to communicate with other work areas (Axtell et al., 2000); communication across

work areas may support continued improvement after a Kaizen event (Tennessen and Tonkin, 2008). As a part of *experimentation,* "team action is taken to test hypotheses or to discover and assess impact of action" (Groesbeck, 2001, p. 71). Active experimentation with new ideas (Upton, 1996) has been found to be a key component of learning and knowledge development which may influence improvement outcome sustainability. *Internal collaboration* refers to the extent to which "team members synthesize their divergent views such that apparent conflicts are resolved through dialectical thinking, not compromise or majority rule" (Groesbeck, 2001, p. 71). Through *internal collaboration*, work area employees are able to share experiences and lessons learned with peers; this exchange may influence improvement sustainability (e.g., Kaye and Anderson, 1998). Finally, *group stewardship* is defined as "a collectively held sense of responsibility to oversee and improve performance in the group's area of responsibility in accordance with the best interests of the organization" (Groesbeck, 2001, p. 48-49). The stewardship, or collective responsibility, of a group of work area employees may relate to their commitment to the improvement which may influence improvement outcome sustainability (e.g., Mann, 2005).

Work area routineness measures the general complexity of the target system, based on the level of stability of the product mix and degree of routineness of product flow (Farris, 2006). Although not explicitly mentioned in the Kaizen event and general process and continuous improvement sustainability literature, one can infer that the complexity of a work area may impact the complexity and scope of an improvement effort; increased levels of project scope and project complexity may negatively impact sustainability of improvement (Keating et al., 1999).

Finally, while previous research has not directly studied the potential influence that objective changes in a work area after an improvement effort, related findings support their inclusion in the model. For example, a work area with a higher number of *production system changes* (including changes to work area equipment, product volume and product mix) may indicate that the work area is less stable, which may negatively influence improvement sustainability (Keating et al., 1999). Also, higher levels of *workforce changes* (including work area employee and management turnover) may indicate a lack of job security and a loss of knowledge in the work area which may negatively influence improvement sustainability (Dale et al., 1997; Keating et al., 1999).

2.7.3 Post-Event Characteristics

The present research identified and measured three Post-Event Characteristics: *institutionalizing change*, *improvement culture*, and *performance review*. The factors relate to the processes that have been found to impact change sustainabilty. Specifically, the individual factor items within these three measures refer to the socialization of the change (socialization), commitment of the individual to the change (commitment), the allocation of rewards based on the pursuit of behaviors that support the change (reward allocation), and processes used to measure the degree of institutionalization, feedback information, and corrective actions (sensing and recalibration) (Goodman and Dean, 1982; Cummings and Worley, 1997). The following describes each factor as supported by the relevant Kaizen event and general process improvement literature.

Institutionalizing change is defined in this research as a set of activities conducted to complete the implementation of changes and actions identified in the Kaizen event and to incorporate changes into the ongoing, everyday activities of the organization (Jacobs, 2002). Literature supporting this factor includes the Kaizen event sustainability research of Bateman (2005). Her research found that completing the Plan-Do-Check-Act cycle in closing out action items, including the formal recording of ideas and the formal introduction of new work methods, was a general enabler for process improvement sustainability. Specific practices related to *institutionalizing change* include training employees in new work methods (Heard, 1997; Goldacker, 2005), providing support for employees to complete action items after the event (Magdum and Whitman, 2007), and documenting changes to work methods (Miller, 2004; Patil, 2003; Magdum and Whitman, 2007).

Improvement culture is defined in this research as the encouragement of organizational improvement through management's support of the use of Kaizen events and continuous improvement activities among work area employees and Kaizen event team members. The existence of such efforts can be observed through management's support of work area employees and Kaizen event team members. For instance, Bateman and Rich (2003) identified a lack of management support as an inhibitor of Kaizen event sustainability. Specific practices related to *improvement culture* include recognition of employees (Oxtoby et al., 2002), management support of a continuous improvement culture (Bateman and Rich, 2003; Kaye and Anderson, 1999), and allowance of time to work on continuous improvement activities (Bateman, 2005).

Performance review is defined in this research as the extent to which the organization measures and evaluates the results of the Kaizen event. The literature emphasizes the regular use of performance measurement and assessment mechanisms. For example, Kaye and Anderson (1999) identified the establishment of performance measurement and feedback systems as a key criterion for continuous improvement. Specific practices related to *performance review* include the review of Kaizen event performance measurement data (Kaye and Anderson, 1999; Bateman, 2005), use of audits and audit reporting tools (Kaye and Anderson, 1999; Martin and Osterling, 2007; Patil, 2003), regular follow-up meetings of the Kaizen event team (Martin and Osterling, 2007; Palmer, 2001), and regular follow-up reports and meetings to management (Goldacker, 2005; Destefani, 2005; Magdum and Whitman, 2007).

2.7.4 Sustainability Outcomes

This research identified and measured three technical system outcomes and two social system outcomes: *goal sustainability, result sustainability, impact on area sustainability, work area attitude*, and *work area commitment*. All of the outcome variables were adapted from variables originally developed by Doolen et al. (2003) and Farris (2006). These outcomes also relate to the institutionalization models. *Goal sustainability* and *result sustainability* relate to the extent to which the change has improved the overall performance of the work area (Buller and McEvoy, 1989). *Impact on area sustainability* relates to the extent to which the change has a lasting impact on the work area (Buller and McEvoy, 1989). *Work area attitude*, relates to the extent to which the work area employees like or dislike the change (Goodman and Dean, 1982) and *work area commitment* refers to the work area employees' belief in the value and need of the change mechanism (Buller and McEvoy, 1989). The following describes each factor as supported by the relevant Kaizen event and general process improvement literature.

Goal sustainability compares current (T1) performance to the targeted (T0) goals of the work area (Patil, 2003; Magdum and Whitman, 2007), while *result sustainability* compares current (T1) performance to the recorded (T0) performance from the conclusion of the improvement effort (Bateman, 2005; Magdum and Whitman, 2007). The perception of the lasting impact of a Kaizen event on a work area, i.e., *impact on area sustainability,* may have implications for both technical system results and social system outcomes (Keating et al., 1999) Regarding the inclusion of the Sustainability Outcomes *work area attitude* and *work area*

66

commitment, previous Kaizen event research, including Kaizen event outcome sustainability research, suggests that social system and technical system outcomes may be positively correlated (Farris, 2006; Magdum and Whitman, 2007), thus providing additional support for a socio-technical systems perspective, specifically the inclusion of social system outcomes *work area attitude* and *work area commitment* in the present research.

CHAPTER 3: RESEARCH METHODS

This research uses a multi-site field study design. The following sections describe the research methods used to collect data and prepare the data for analysis.

3.1 Data Collection Instruments

As mentioned previously, the term "T0 data" is used in this research to refer to data collected during and immediately after a Kaizen event. T0 data were collected through three instruments, the Kickoff Survey, Report Out Survey, and Event Information Sheet, administered to Kaizen event teams (Kickoff and Report Out Survey) and facilitators (Event Information Sheet). These instruments were created and used in the study of initial Kaizen event success (Farris, 2006). The present research uses these instruments as well, although not all the variables measured through these instruments were used in the current research. Table 8 describes each T0 data collection instrument and displays the variables that were used in the present study. For more detailed information about each instrument, please refer to Farris (2006) and Farris et al. (2009).

Table 8. T0 Data Collection Instruments and Variables used in the Present Research

Instrument	Variables Measured in the Present Research	Timing	Description	Data Source
Kickoff Survey	• Goal Clarity • Goal Difficulty	Immediately following the kickoff meeting at the beginning of the Kaizen event	19 item survey questionnaire with cover page and instructions	Team
Report Out Survey	• Management Support • Impact on Area	Immediately following the report-out of team results at the end of the Kaizen event.	39 item survey questionnaire with cover page and instructions	Team
Event Information Sheet	• Work Area Routineness • Team Functional Heterogeneity • Goal Achievement	Following the report-out meeting – target was one to two weeks after the event	15 item questionnaire with cover page and instructions	Facilitator

Meanwhile, the term "T1 data" is used in this research to refer to data that were collected approximately 9-18 months after a Kaizen event. T1 data were collected through one questionnaire, the Post Event Information Sheet (PEIS), that was administered either to the facilitator of the Kaizen event or to the work area manager. The questionnaire was either self-administered or a member of the research team gathered the questionnaire data via a telephone interview. The collection method was based on the preference and availability of the respondent. Using this mixed collection method could introduce some bias in the data. However, because a majority of the measures were either objective measures or related to the extent to which objectively observable activities were conducted (e.g., Post-Event Characteristics), the benefits of being able to collect more data were preferred over this potential bias, which was perceived as minimal. The PEIS captures information about the impact of the Kaizen event on the work area as well as work area characteristics and Kaizen event follow-up mechanisms. Table 9 describes the variables from the PEIS that were used in the present study. The PEIS is presented in Appendix C.

Table 9. T1 Data Collection Instrument

Instrument	Variables Measured	Timing	Description	Data Source
Post Event Information Sheet	• Goal Sustainability • Result Sustainability • Impact on Area Sustainability • Work Area Attitude • Work Area Commitment • Improvement Culture • Institutionalizing Change • Performance Review • External Perspective • Experimentation • Internal Collaboration • Group Stewardship • Knowledge of Continuous Improvement • Management Kaizen Event Participation • Workforce Changes • Production System Changes	9-18 months after the Kaizen event	Survey questionnaire with cover page and instructions	Facilitator

3.2 Data Collection Procedures

To ensure that a similar sample was collected during phase one of the OSU-VT research and the present research, the same boundary conditions, company selection, Kaizen event sampling methods, and mechanics of the data collection procedures were used in both phases (Farris, 2006; Farris et al., 2009). The boundary conditions used to select organizations were: the organizations manufacture products of some type, had been conducting Kaizen events for at least one year prior to the start of the study, had been using Kaizen events systematically, and had been conducting Kaizen events relatively frequently, i.e., at least one event per month. Regarding the company selection, organizations were selected based on their willingness to participate and researcher-to-company relationships. At T0, Kaizen events were sampled randomly within each organization. Four organizations (A, B, C, and R) agreed to provide data for all events conducted during the study period; therefore a census sampling approach was used in those organizations. The other organizations requested a lower data collection frequency. In these organizations, a systematic sampling procedure was used (Scheaffer et al., 2006). Where the average number of events in the company per month was some number n, a k was selected between one and n, such that every k^{th} event was targeted for study. For most organizations, the actual sampling frequency was slightly lower than the target sampling frequency due to non-response.

The following inclusion criteria were used to determine whether events (or organizations) could be included in the final dataset due to missing data. A T0 team member response rate of at least 50% of the team for the Kickoff and Report Out Surveys was required for each event in order to have a representative amount of responses per team. Also, an organization had to return completed data for at least four Kaizen events to be included in the dataset.

The following explains the total number of events studied and retained throughout the OSU-VT Kaizen event research initiative (Table 10). The OSU-VT research team collected T0 data from 56 Kaizen events across six manufacturing organizations between October 2005 and June 2006. An event from a seventh organization (Org. Q) was collected during the final weeks of this period (May 2006). This event was not analyzed as a part of the phase one dataset but was counted and analyzed as a part of the present research's T0 dataset. Five individual events were ultimately removed from the analysis because they did not meet the aforementioned

inclusion criterion, leaving a final sample size of 51 Kaizen events (Farris, 2006; Farris et al., 2009).

From July 2006 to July 2008, the OSU-VT research team collected T0 data from an additional 46 Kaizen events across a total of 15 organizations, including four of the six original organizations. Fourteen Kaizen events were removed from this T0 dataset because they did not meet the aforementioned inclusion criterion. Five of the fourteen Kaizen events (from Organizations G, R, and U) were removed because of a low team member response rate at T0. Nine of the 14 Kaizen events were removed because there were less than four Kaizen events per organization with complete data (Orgs. T, U, V, W, X, and Y). Therefore, this research combines the data analyzed in Farris (2006) with the additional data for a total T0 dataset of 83 Kaizen events across nine organizations.

From October 2006 to April 2009, the OSU-VT research team attempted to collect data from all of the 83 Kaizen events that were studied. However, in 15 of the 83 Kaizen events studied at T0, the T1 data were not returned (i.e., these are non-response cases). Therefore, there were a total of 68 responses at T1. Two of the 68 events were removed from the dataset because less than half of the PEIS questions were completed (in these cases, the OSU-VT team did attempt to retrieve the data from the participant, but requests were not fulfilled). One of the 68 events was considered inappropriate for inclusion because it was still in implementation phase at the time during which the T1 data was scheduled to be collected. Thus, the total sample size (T0 and T1 data) for the present research is 65 Kaizen events.

Table 10: Number of Events Collected During Study Period and Final Count of Events Included in the Present Research

Org.	No. of Events Studied-T0 Data Returned	No. of Events Retained at T0 for Analysis Based on Criteria*	No. of Events Studied-T1 Data Returned	No. of Events Retained at T1 for Analysis Based on Criteria**	Comments
A	19	19	19	19	
B	9	9	5	4	Events 325, 326, 327, 346 removed from Sustainability analysis (PEIS sent but not returned) Event 324 removed from Sustainability analysis (PEIS partially completed; missing responses requested but not returned)
C	11	7	4	4	Events 635, 636, 637, 640 removed from initial (Farris, 2006) analysis due to low Kickoff Survey and Report Out survey response rates Events 616, 618, 638 removed from Sustainability analysis (PEIS sent but not returned)
D	7	7	0	0	Organization D withdrew from study before sustainability data were collected
E	16	15	15	13	Event 101 removed from initial (Farris, 2006) analysis (Only one individual fully completed the Kickoff Survey while others skipped multiple questions) Event 105 removed from Sustainability analysis (still in implementation phase) Event 110 removed from Sustainability analysis (PEIS partially completed; missing responses requested but not returned)
F	7	7	7	7	
G	8	7	7 [a]	7	Event 1801 removed from analysis (low Kickoff Survey and Report Out survey response rates)
Q	6	6	5	5	Event 1701 removed from Sustainability analysis (PEIS sent but not returned)
R	8	6	6 [a]	6	Event 1901 and 1902 removed from analysis (low Report Out Survey response rates)
T	2	0	0 [a]	0	Dropped out of study due to having less than 4 events

U	4	0	0[a]	0	Events 2001 and 2001 removed from analysis (low Kickoff Survey and Report Out survey response rates) Events from this company removed from analysis
V	2	0	0	0	Dropped out of study due to having less than 4 events
W	1	0	0	0	Dropped out of study due to having less than 4 events
X	1	0	0	0	Dropped out of study due to having less than 4 events
Y	1	0	0	0	Dropped out of study due to having less than 4 events
Totals:	102	83*	68	65*	

* at least 50% for the Kickoff and Report Out Surveys was required for each event and the organization had to return completed data for at least four Kaizen events
**Of the 83 events, the PEIS was returned, more than half of the PEIS questions were completed, the event was deemed appropriate for inclusion in the dataset, and the organization had to return completed data for at least four Kaizen events
[a] It should be noted that an additional nine PEIS were collected from Kaizen events in organizations that did not have complete T0 datasets (Org G=1, Org R=2, Org. T=2, Org. U=4.). In the case of Org. V, the PEIS were collected because it was possible that the research team could collect additional data from the organizations, but ultimately, this did not occur. In the other cases, the PEIS was collected before the T0 data were fully screened; a complete dataset (T0 and T1 data) is needed for a given event, therefore these data were automatically excluded.

Table 11 summarizes the final count of events included in the study. Appendix D provides a description of the organizations that are included in the final analyses and Appendix E provides detail regarding the Kaizen events studied.

Table 11. Final Count of Events Included in the Study

Organization	Description	Number of events
A	Secondary wood product manufacturer	19
B	Electronic motor manufacturer	4
C	Secondary wood product manufacturer	4
E	Specialty equipment manufacturer	13
F	Steel component manufacturer	7
G	Aerospace engineering and manufacturer	7
Q	IT component manufacturer	5
R	Aerospace engineering and manufacturer	6
Total:		65

3.3 Operationalized Measures for Study Factors

The following sections present the operationalized measures for the Sustainability Outcomes, Work Area Characteristics, and Post-Event Characteristics.

3.3.1 Operationalized Measures for Sustainability Outcomes

The technical system Sustainability Outcomes are *result sustainability*, *goal sustainability,* and *impact on area sustainability*. Table 12 includes the formula as well as the input data collected for each construct at T0 and T1. It should be noted that the originally proposed measure of *impact on area sustainability* was ultimately modified to only include the T1 input data based on the results later in the research process (see Section 4.3).

Table 12. Operationalized Technical System Sustainability Outcomes

Construct	Calculation	Input Data at T0	Input Data at T1
Result Sustainability	*T1 Performance* ÷ *T0 Performance*	*T0 Performance on Goals-* The level of the performance on the primary goals at the conclusion of the Kaizen event	*T1 Performance on Goals-* The current level of the performance on the primary goals
Goal Sustainability	*% Goal Achieved* (T1) ÷ *% Goal Achieved* (T0)	Data Collected through *EIS* *Team Goals-* The Kaizen event goals *Performance on Goals-*The current level of the performance on the primary goal *%Goal Achieved (T0)* is computed as the % of primary goals met at *T0*	Data Collected through *PEIS* *Team Goals-* The Kaizen event goals at *T0* *Performance on Goals-*The current level of the performance on the primary goal *%Goal Achieved (T1)* is computed as the % of primary goals met at *T1*

Impact on Area Sustainability	*Impact on Area (T1)* ÷ *Impact on Area (T0)*	Data Collected through *Report-Out Survey*	Data Collected through *PEIS*
		Three-item scale, *Impact on Area,* developed by Farris, 2006; measured using a 6-point Likert response scale:	Three-item scale, *Impact on Area,* developed by Farris, 2006; measured using a 6-point Likert response scale
		IMA1: The Kaizen event has had a positive effect on the work area. IMA2: The work area has improved measurably as a result of the Kaizen event. IMA3: The Kaizen event has improved the performance of the work area.	IMA1: The Kaizen event has had a positive effect on the work area. IMA2: The work area has improved measurably as a result of the Kaizen event. IMA3: The Kaizen event has improved the performance of the work area.

Event goals, T0 performance, and T1 performance were categorized across all events to ensure that all *goal sustainability* and *result sustainability* values were calculated similarly and according to a defined rubric. The categorization rubric used to calculate *goal sustainability* and *result sustainability* is presented in Table 13. The steps used to categorize the goals for each event are as follows:

- Step 1: Categorize the goal (A, B, or C)
- Step 2: Categorize the event as an implementation or non-implementation event based on the event goals and T0 performance (n is used to identify non-implementation events)
- Step 3: Categorize the T0 Performance (1, 2, 3, 4, or 5)
- Step 4: Categorize the T1 Performance (1, 2, 3, 4, 5, or 6)

The abbreviations used in Table 12 are:

- GA: *Goal Achievement* (T0 Results v. Goal)
- GS: *Goal Sustainability* (T1 Results v. Goal)
- RS: *Result Sustainability* (T1 Results v. T0 Results)

Table 13: Categorization Rubric for Event Goals, T0 Performance, and T1 Performance

Goal Description	Goal Category	# Primary Goals
Objectively measurable goal with target stated Examples: Reduce throughput time by 80% Increase productivity by 50% (from 1.8 pieces/hr to 2.7 pieces/hr)	A	61

Objectively measurable goal without target stated
    GA and GS = 0% or 100%
    RS= any percentage as the T0 Results can be compared with T1 Results
Examples:
Reduce throughput time
Increase productivity
Improve quality
	B	20

Goal that does not have one clear metric or does not imply a clear performance metric Examples: Improve work flow Standardize process Create future state layout for department X For non-implementation events, if a future plan is developed, implementation is expected at T1	C	99

T0 Results-Implementation v. Non-implementation	Non-Imp Category	# Primary Results
T0 results are projections or expected results Primarily used for goals from non-implementation events; used for 3 implementation goals If T0 Results = TBD, GA=100% because it is a non-implementation event (assuming goal will be achieved if future state is implemented) If T0 Results = a single, objectively measurable value, GA is based on the value presented	n	23

T0 Results Description	T0 Results Category	# Primary Results

T0 results are expressed in objectively measureable units
    Includes result not expressed in the same unit as the goal, but because of the context of response and addl. information sources such as RO files, the units can be interpreted
    GA can be any real number (expressed as a percentage)
	1	50

T0 results are expressed or can be interpreted as 'achieved' or 'not achieved' Includes results that are expressed qualitatively (e.g., "limited communication" or "takes weeks") GA= 0% or 100%	2	77
T0 results are expressed as an approximation Most conservative bound of the estimate is used in calculations GA=any percentage Examples: Result between X and Y (avg. used) Result higher than X (X used) X out of Y people use the new process (X/Y used) Item 1 complete; Item 2 not complete (50% used)	3	4

T0 results are to be determined (TBD)
    If part of an Implementation Event: GA=0%
    If part of an Non-Implementation Event: GA=100%
	4	6

T0 results were not reported by the respondent not answered- question not answered by respondent	5	3

T1 Current Performance	T1 Current Performance Category	# Primary Results
not measured- respondent reports that the value is unknown or not measured		

T1 results are expressed in objectively measureable units
    Includes result not expressed in the same unit as the goal, but because of the context of response and addl. information sources such RO files, the units can be interpreted
    GS and RS can be any real number (expressed as a percentage)
	1	50

T0 results are expressed or can be interpreted as 'achieved' or 'not achieved' Includes results that are expressed qualitatively (e.g., "limited communication" or "takes weeks") GS and RS= 0%, 100%, or GA	2	70
T1 results are expressed as an approximation Most conservative bound of the estimate or the T0 result is used in calculations GS and RS= any percentage (2 cases highlighted for questions currently 'n/a') Examples: Result between X and Y (avg. used) Result higher than X (X used) X out of Y people use the new process (X/Y used) Item 1 complete; Item 2 not complete (50% used)	3	16

T1 results are to be determined (TBD)
    Occurs in cases where [full] implementation has not occurred, and thus the respondent reported that the final results are yet to be determined
    GS=RS
	4	5

T1 results were not reported by the respondent
    not answered- question not answered by respondent
    not measured- respondent reports that the value is unknown or not measured
	5	16

Results do not apply at T1 due to a work area change or an implementation that is unlikely to be undone For these cases, current performance often recorded as N/A (respondent reported "not applicable") or Not Asked (question not asked/included in PEIS by researcher because it was not applicable at T1) Goal not considered in overall event GS or RS calculation Examples: "One Time "Goals, e.g., evaluate X; one time training of employees; physical change to a piece of equipment Major change in Work Area (moved to another building or no longer exists)	6	23

The social system Sustainability Outcomes are *work area attitude* and *work area commitment*. *Work area attitude* is similar to the initial Kaizen event outcome *work area attitude* (Farris, 2006), but in this research is adapted to refer to the work area employees and management as opposed to the Kaizen event team. Finally, *work area commitment* captures the influence of the Kaizen event on the extent to which management and work area employee believe in the value of and need for Kaizen events. These measures were only captured at one time point (T1) and are described in Table 14.

Table 14. Operationalized Social System Sustainability Outcomes

Construct	Input Data
Work Area Attitude Data Collected through *PEIS* Three-item scale developed by Farris, 2006; measured using a 6-point Likert response scale	AT1: In general, the Kaizen event has increased work area employees' willingness to be part of Kaizen events in the future. AT2: In general, the Kaizen event has improved work area management's attitude toward Kaizen events. AT3: In general, the Kaizen event has improved work area employees' attitudes toward Kaizen events.
Work Area Commitment Data Collected through *PEIS* Five-item scale adapted from Herscovitch and Meyer (2002); measured using a 6-point Likert response scale	CKE1: In general, the Kaizen event has increased Work area management's belief in the value of Kaizen events CKE2: In general, the Kaizen event has increased Work area employees' belief in the value of Kaizen events CKE3: In general, the Kaizen event has increased Work area employees' belief that Kaizen events are a good strategy for this organization. CKE4: In general, the Kaizen event has increased Work area employees' belief that Kaizen events serve an important purpose. CKE5: In general, the Kaizen event has increased Work area employees' belief that Kaizen events are needed in this organization.

3.3.2 Operationalized Measures for Kaizen Event Characteristics

The Kaizen Event Characteristics considered in the model of Kaizen event sustainability potential factors of initial Kaizen event success (Farris, 2006) were presented in Chapter 2. These factors, labeled Kaizen Event Characteristics in this study, are T0 data and were included in the present research to assess the extent to which they might also be critical to the sustained success of Kaizen events, the logic of which was described in Chapter 2. These factors are described in Table 15.

Table 15. Operationalized Measures for Kaizen Event Characteristics (from Farris, 2006)

Construct	Construct Items/Measurement
Goal Clarity Data Collected through *Kickoff Survey*	GC1: Our team has clearly defined goals. GC2: The performance targets our team must achieve to fulfill our goals are clear. GC3: Our goals clearly define what is expected of our team.

Four-item scale; measured using a 6-point Likert response scale.	GC4: Our entire team understands our goals.
Goal Difficulty Data Collected through *Kickoff Survey* Four-item scale; measured using a 6-point Likert response scale.	GDF1: Our team's improvement goals are difficult. GDF2: Meeting our team's improvement goals will be tough. GDF3: It will take a lot of skill to achieve our team's improvement goals. GDF4: It will be hard to improve this work area enough to achieve team's goals.
Team Functional Heterogeneity Data Collected through *Event Information Sheet*	Measured by an index of variation for categorical data, *H* (Shannon, 1948), as reported in Teachman (1980). Categories were the job function of each team member – e.g., operator, technician, engineer, supervisor, manager, other – as reported by the facilitator.
Management Support Data Collected through *Report out survey* Three-item scale; measured using a 6-point Likert response scale.	MS2: Our team had enough materials and supplies to get our work done. MS3: Our team had enough equipment to get our work done. MS5: Our team had enough help from others in our organization to get our work done.

3.3.3 Operationalized Measures for Work Area Characteristics

As described in Chapter 2, Kaizen event outcome sustainability may also be influenced by Work Area Characteristics. Work group effectiveness theory constructs (Groesbeck, 2001) and a continuous improvement construct (Doolen et al., 2003) are used in order to operationalize Work Area Characteristics. The majority of the Work Area Characteristics were collected through items included in the PEIS and one Work Area Characteristic, *work area routineness*, was collected through the Event Information Sheet at T0. The perceptual Work Area Characteristics were measured using a 6-point Likert response scale and are *work area routineness, external perspective, experimentation, internal collaboration, group stewardship,* and *knowledge of continuous improvement*. The items for each construct are presented in Table 16.

The PEIS also included Work Area Characteristics that operationalized changes in management's participation in Kaizen events, employee and management turnover as they relate to the Kaizen event, and changes related to the production system. It was expected that underlying relationships may exist between subsets of these variables, therefore nonlinear PCA

as described in Section 3.5.2 was used to analyze these proposed relationships. The factors and their corresponding proposed component(s) are also included in Table 16.

Table 16. Operationalized Measures for Work Area Characteristics

Construct/Variable	Construct Items/Variable Input Data
Work Area Routineness Data Collected through *Event Information Sheet* Four-item scale (Farris, 2006); Measured using a 6-point Likert response scale.	WAC1: The work the target work area does is routine. WAC2: The target work area produces the same product (SKU) most of the time. WAC3: A given product (SKU) requires the same processing steps each time it is produced. WAC4: Most of the products (SKUs) produced in the work area follow a very similar production process.
External Perspective Three-item scale adapted from Groesbeck (2001)	EP1: Work area employees understand how their work fits into the "bigger picture" of the organization. EP2: Work area employees try to think how the different parts of the organization fit together. EP3: Work area employees understand how their work relates to that of other parts of the organization.
Experimentation Two-item scale adapted from Groesbeck (2001)	EXPER2: Work area employees try out new things by applying them in practice. EXPER3: Work area employees test new ideas to help themselves learn.
Internal Collaboration Three-item scale adapted from Groesbeck (2001)	INT1: Work area employees ask each other questions when they are uncertain about something. INT2: Work area employees ask each other for help when they need assistance. INT3: Work area employees freely share information with one another.
Group Stewardship Three-item scale adapted from Groesbeck (2001)	STEW1: Work area employees feel a shared sense of responsibility for the work they do. STEW2: Work area employees feel a sense of accountability for the work they do. STEW3: Work area employees want to do what is best for the organization.
Knowledge of Continuous Improvement Four-item scale adapted from Doolen et al. (2003)	KCI1: Work area employees understand what continuous improvement is. KCI2: Work area employees understand how continuous improvement can be applied to Work area. KCI3: Work area employees believe there is a need for continuous improvement in Work area. KCI4: Work area employees believe they have a role in continuous improvement in Work area.

Management Kaizen event Participation (MKP) *One variable*	Polynomial variable PEIS Questions: Have the current managers all participated in at least one Kaizen event? (1=yes, 2=no) At the time of the Kaizen event, had work area managers all participated in at least one Kaizen event? (1=yes, 2=no) Data for Analysis: • management Kaizen event participation = 0, referred to as Case 0: when current management had NOT participated in at least one Kaizen event at the time of the observed Kaizen event AND current management had NOT participated in at least one Kaizen event since the observed Kaizen event • management Kaizen event participation = 1, referred to as Case 1: when current management had participated in at least one Kaizen event at the time of the observed Kaizen event AND current management had NOT participated in at least one Kaizen event since the observed Kaizen event • management Kaizen event participation = 2, referred to as Case 2: when current management had NOT participated in at least one Kaizen event at the time of the observed Kaizen event AND current management had participated in at least one Kaizen event since the observed Kaizen event • management Kaizen event participation = 3, referred to as Case 3: when current management had participated in at least one Kaizen event at the time of the observed Kaizen event AND current management had participated in at least one Kaizen event since the observed Kaizen event
Workforce Changes *Combination of two variables*	Binomial variable PEIS Question: Management Change: Has work area management changed since the Kaizen event? (1=yes, 2=no)
	Continuous variable PEIS Questions: Employee Change: The number of current employees in the work area that were working in the work area at the time of the Kaizen event The number of current employees in the work area Measured as: The number of current employees in the work area that were working in the work area at the time of the Kaizen event ÷ The number of current employees in the work area

Production system changes *Combination of three variables*	Binomial variable PEIS Question: Equipment Change Have there been any major equipment changes in the work area since the Kaizen event? (1=yes, 2=no)
	Binomial variable PEIS Question: Volume Change Have there been any major volume changes in the work area since the Kaizen event? (1=yes, 2=no)
	Binomial variable PEIS Question: Product Mix Change Have there been any major product mix changes in the work area since the Kaizen event? (1=yes, 2=no)

3.3.4 Operationalized Measures for Post-Event Characteristics

As described in Chapter 2, the practitioner and scholarly literature suggests that companies use or exhibit certain mechanisms or characteristics, referred to as Post-Event Characteristics, after the conclusion of a Kaizen event in order to sustain results. All Post-Event Characteristics data were collected through items included in the PEIS and measured using a 6-point Likert response scale.   The items relate to the extent to which certain Post-Event Characteristics were used. This research proposes three Post-Event Characteristics: *institutionalizing change*, *improvement culture*, and *performance review*. The construct items are presented in Table 17.

Table 17. Operationalized Measures for Post-Event Characteristics

Construct	Construct Items
Institutionalizing Change Six-item scale adapted from Kaizen event literature presented in Ch.2	IChange1: Formal documentation of follow-up action items (e.g., through a Kaizen newspaper) from the Kaizen event. IChange2: Individual team members working on follow-up action items from the Kaizen event. IChange3: Training work area employees in new work methods and processes from the Kaizen event. IChange4: Updating work method and process documentation (e.g., standard work charts, formal job descriptions, etc.) for changes made due to the Kaizen event. IChange5: Involving work area employees (not on the Kaizen event team) in follow-up and completion of action items from the event. IChange6: Providing work area employees with freedom to make changes to work area.
Improvement Culture Eight-item scale adapted from Kaizen event literature presented in Ch.2	ICulture1: Rewarding or recognizing Kaizen event team members for their contributions. ICulture2: Rewarding or recognizing work area employees (not only those on the Kaizen event team) for progress on sustaining changes or completing action items from Kaizen event. ICulture3: Avoiding blame or negativity when changes are made, but results are different than expected. ICulture4: Avoiding blame or negativity when team goals are not achieved. ICulture5: Work area management encouraging work area employees to apply continuous improvement knowledge and skills. ICulture6: Work area management supporting the use of Kaizen events in the organization. ICulture7: Work area management championing the value of continuous improvement. ICulture8: Work area management allowing work area employees time to work on continuous improvement activities.
Performance Review Seven-item scale adapted from Kaizen event literature presented in Ch.2	PR1: Regularly reviewing performance data related to Kaizen event goals. PR2: Conducting regular audits on changes made due to the Kaizen event. PR3: The Kaizen event team meeting as a whole to review progress and/or develop follow-up strategies for the Kaizen event. PR4: Meetings with higher-level management about Kaizen event progress or follow-up. PR5: Meetings with Kaizen coordinator or facilitator about Kaizen event progress or follow-up. PR6: Meetings with work area management about Kaizen event progress or follow-up. PR7: Informing higher-level management of issues with follow-up and sustaining results from the Kaizen event.

3.4 Data Screening

All data were manually entered into two separate Excel workbooks. As described in Section 1.5, all organizations were limited geographically to within a day's drive of either VT (East Coast organizations) or OSU (West Coast organizations). The author entered the new T0 and T1 data that were collected from Kaizen events studied in organizations on the East Coast. Another member of the OSU-VT research team entered the T0 and T1 from events studied in organizations on the West Coast. The author compiled the data into a single Excel spreadsheet and verified their accuracy by visually checking the single spreadsheet against the original spreadsheets.

3.4.1 Summary of T0 Individual Survey Scale Item Data Screening

All individual T0 Kickoff and Report Out surveys were thoroughly screened for signs of survey fatigue and lack of variation in response or bimodality. The standard deviation across both surveys was calculated and assessed for zero standard deviation. Next, for the Kickoff Survey, the standard deviation across the last half (nine) of the scale items was calculated and assessed for zero standard deviation. For the Report Out Survey, page two of the survey (i.e., items 19-35) were assessed for standard deviation.

Next, the descriptive statistics, histograms, and tests of normality were conducted to examine distributional properties. For both the Kickoff and Report Out Survey, all survey scale items had relatively symmetrical distributions. The minimum and maximum values indicated that, in general, respondents were using the entire survey scale. While the responses were generally negatively skewed , the skewness values do not deviate from normality severely enough, i.e., no values greater than 2.0 (DeCarlo, 1997) and the relative symmetry suggests that departures from normality are not extreme and the questions can be used in statistical analysis. Of the n=65 events analyzed in the present analysis, there were 509 individual Kickoff Surveys and 420 individual Report Out Surveys.

3.4.2 Summary of T1 PEIS Individual Survey Scale Item Data Screening

The author examined each scale item from the PEIS to assess their adherence to the basic statistical assumptions to perform further analysis (Neter et al., 1996; Johnson, 1998; Field, 2009). First, the mode of each survey scale item was examined to determine if any items had a

mode equal to the high scale value – i.e. 6. None of the survey items had a mode equal to 6. However, the majority of the items did have a mode equal to 5 (44 out of 64 scaled items). The means of the items ranged from 2.57 to 5.33. The maximum response for all items was 6. The minimum response for most items was 1 (37 items), followed by 2 (18 items) and 3 (nine items). The histograms revealed that the distribution for each item was relatively symmetric. A majority of items are negatively skewed, indicating that the values clustered to the right, with the tail extending to the left. Eight out of 64 items were positively skewed. Overall, the data appear to be non-normal but the skewness values do not deviate from normality severely enough, i.e., no values greater than 2.0 (DeCarlo, 1997), to exclude them from analysis.

3.5 Data Reduction

3.5.1 Data Reduction Methods of T1 Perceptual Measures

Factor analysis was used to assess construct validity, or how well the proposed construct items measure the proposed underlying constructs (Emory and Cooper, 1991). The present research uses exploratory factor analysis (EFA) to examine the quality of items and factor loadings of all perceptual measures. EFA was chosen over other factor analysis methods, particularly confirmatory factor analysis (CFA). CFA allows the researcher to identify the proposed underlying constructs that accounts for the variation and covariation among a set of indicators or items and all aspects of the model's structure must be specified, usually based on theory and/or previous empirical research (Thompson, 2004). EFA is also commonly used to explore proposed underlying constructs, but without specifying a preconceived structure on the model (Thompson, 2004). Because of the exploratory nature of the present research, the fact that many of the proposed constructs have not been tested extensively in prior research, and in the case of the Post-Event Characteristics, some of the proposed constructs have not been tested at all, EFA was used to examine the validity of the proposed constructs.

EFA is the process by which researchers are able to reduce the amount of data that is considered by determining which variables can be grouped together because of their high correlations amongst each other and relatively lower correlations amongst other variables (Johnson and Wichern, 2007). In order to conduct factor analysis, a researcher must determine whether or not the data is approximately normal, choose a model fitting method, and choose a fit rotation method. To account for non-normality, this research uses the principle component

method of factor analysis, the preferred method for non-normal data (Johnson and Wilchern, 2007).

Next, the factor rotation technique must be determined. Oblique rotations allow for correlated factors which can produce more useful patterns and lend greater flexibility in finding patterns regardless of their correlation (Jennrich, 2002; Johnson and Wichern, 2007). The oblique rotation method family *oblimin* describes a class of models that involve oblique factors and minimizing criteria. Of the *oblimin* models, the most oblique model, the *quartimin* rotation, is used to allow maximum model flexibility (Jennrich, 2002). Following Kaiser's rule, components with an eigenvalue greater than 1.0 were extracted (Johnson, 1998). Finally, examination of the data scree plots assisted in choosing the number of principle components to retain in the model (Johnson, 1998; Johnson and Wichern, 2007).

Because the data collected with the PEIS are nested as teams within organizations, the data are not truly independent which may alter the calculation of statistical significance (Johnson, 1998). Thus, only items with high primary loadings (>.500) and low secondary loadings (<.300) are accepted as items of the final factor set. Unexpected factors that emerge from the analysis are allowed. The previous research of Farris (2006) assessed the Kaizen Event Characteristics via EFA. Therefore, the current research presents only the factor analysis results of the T1 factors. For the analysis of T1 factors, n_{T1}=65 which meets the minimum observation to item ratio of 2:1 although it does not meet the preferred observation to item ratio of 10:1 (Kline, 2005). Due to the fact that the Sustainability Outcomes were hypothesized to be direct linear combinations of the Work Area Characteristics and Post-Event Characteristics and because the Post-Event Characteristics were hypothesized to mediate the relationship between the Sustainability Outcomes and the Work Area Characteristics, three EFA models were created: a perceptual Work Area Characteristics model, a Post-Event Characteristics model, and a Sustainability Outcomes model. Meaningful loadings, i.e., greater than 0.500, where all cross-loadings are less than 0.300, are shown in bold and loadings less than 0.250 are suppressed in the pattern matrices presented in the following sections.

3.5.2 EFA of Sustainability Outcome Survey Scales
The pattern matrix for the perceptual Sustainability Outcomes, *impact on area* (the T1 measure), *work area attitude* and *work area commitment* is provided in Table 18. A two-factor solution was examined because the initial eigenvalues for the first two components were 7.16 (65.04% of

total variance) and 1.72 (15.65 of total variance) and the next largest component was less than one (0.60). The construct validity of the *impact on area* (T1) scale was supported and all items loaded onto component two (lowest primary loading =0.886). However, the *work area attitude* and *work area commitment* items did not load onto separate factors. Two of the *work area attitude* items (AT1-1 and AT1-3) and four of the *work area commitment* items (CKE1, CKE3, CKE4, CKE5) loaded onto component two (lowest primary loading =0.790). These items are conceptually related as they all refer to the attitudes and commitment of the work area employees.

One item, AT1-3 ("In general, the Kaizen event has improved work area employees' attitudes toward Kaizen events"), had a primary loading that was greater than 1.0 (1.002). Jöreskog (1999) notes that when oblique rotation methods are employed, the factor loadings are regression coefficients and not correlations and as such they can be larger than 1.0 in magnitude. However, a factor loading greater than 1.0 may indicate that multicollinearity may be an issue (Jöreskog, 1999). Upon revisiting the correlation matrix, it is noted that AT1-3 is highly correlated with AT1-2 and CKE1 (0.81 and 0.87 respectively). Field (2009) suggests that while multicollinearity may be an issue when correlation coefficients are greater than 0.80, eliminating highly correlated variables may not address the cause of the multicollinearity. Therefore, the content of the items was reviewed in order to determine which items were to be included in the survey scale.

Interestingly, the two items, AT1-2 ("In general, the Kaizen event has improved the work area management's attitude toward Kaizen events") and CKE1 ("In general, the Kaizen event has increased the work area management's belief in the value of Kaizen events") were the only items that did not cleanly load onto a single component. It appears that these two items did not load to component one because they both relate to management attitudes and beliefs regarding Kaizen events while the other items from component one relate to work area employee attitudes and beliefs toward Kaizen events. In order to explore this issue further, a three component solution was explored and revealed a similar solution where AT1-2 and CKE1 loaded onto the third component. However, the eigenvalue for third component was very low (0.60) and explained only 5.50% of the total variance. Therefore, the two factor solution (excluding AT1-2 and CKE1) was retained. The revised survey scales are presented in Table 19.

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Table 18. Pattern Matrix for Sustainability Outcomes

	Component	
	1	2
AT1-3	**1.002**	
CKE2	**0.948**	
AT1-1	**0.901**	
CKE4	**0.886**	
CKE3	**0.880**	
CKE5	**0.790**	
CKE1	0.645	0.317
AT1-2	0.557	0.396
IMA1-3		**0.978**
IMA1-2		**0.955**
IMA1-1		**0.886**
Initial Eigenvalue	7.16	1.72
Percentage of Variance Explained	65.04	15.65

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
a. Rotation converged in 4 iterations.

Table 19. Revised Sustainability Outcome Survey Scales

Scale	Revised Item List
Work Area Attitude and Commitment	AT1-1: In general, the Kaizen event has increased work area employees' willingness to be part of Kaizen events in the future. AT1-3: In general, the Kaizen event has improved work area employees' attitudes toward Kaizen events. CKE2: In general, the Kaizen event has increased Work area employees' belief in the value of Kaizen events CKE3: In general, the Kaizen event has increased Work area employees' belief that Kaizen events are a good strategy for this organization. CKE4: In general, the Kaizen event has increased Work area employees' belief that Kaizen events serve an important purpose. CKE5: In general, the Kaizen event has increased Work area employees' belief that Kaizen events are needed in this organization.
Impact on Area-T1	IMA1: The Kaizen event has had a positive effect on the work area. IMA2: The work area has improved measurably as a result of the Kaizen event. IMA3: The Kaizen event has improved the performance of the work area.

3.5.3 EFA of Work Area Characteristics Survey Scales

Previous research has found that the group learning behaviors were positively associated with group stewardship (Groesbeck, 2001). However, present research did not find that the items were highly correlated such that there were issues of multicollinearity. Therefore, all of the new Work Area Characteristic survey scale items were explored in the same EFA model. The construct validity of *work area routineness* was conducted during phase one of the OSU-VT research (Farris, 2006; Farris et al., 2009). A one-factor solution and a two-factor solution were examined because the initial eigenvalue for each component was 9.44 (63.16% of total variance) and 0.98 (6.56% of total variance). The third eigenvalue was 0.81 and a three-factor model was explored but no items loaded cleanly to the third component, i.e., no items had a primary loading greater than 0.500 onto the third component and cross-loadings less than 0.300.

Adopting the one-factor solution would result in a collective survey scale that encompasses several learning behaviors, *group stewardship*, and *knowledge of continuous improvement*. Because the second eigenvalue was close to 1.0 (0.98), the two factor solution was explored and adopted.

The pattern matrix for the Work Area Characteristics survey scales is provided in Table 20. In the two factor solution, the first component includes items from the *group stewardship* (STEW1, STEW2, STEW3)*, external perspective* (EP1, EP3), and *internal collaboration* (INT2, INT3) survey scales. These items refer to ways in which work area employees may learn from each other (e.g., INT2: "Work area employees ask each other for help when they need assistance") and how work area employees relate to their work and organization (e.g., EP3: "Work area employees understand how their work relates to that of other parts of the organization" and STEW3: "Work area employees want to do what is best for the organization"). In other words, these items appear to be similar in that they all relate to how a work area employee may relate to their co-workers, work area, and organization. One *knowledge of continuous improvement* item (KCI1: "Work area employees understand what continuous improvement is") loaded to the first component as well, but had a moderately high cross-loading (0.284) and did not have a strong conceptual relationship with the other items. Therefore KCI1 was excluded from the first survey scale. The revised survey scale is referred to as *learning and stewardship*.

The second component includes items related to *experimentation* and *knowledge of continuous improvement*. *Experimentation* and *knowledge of continuous improvement* both represent action-oriented learning behaviors (Yueng et al., 1999), which provides evidence of the relationship between the concepts and supports the EFA findings. The component also included one *external perspective* item EP2 ("Work area employees try to think how the different parts of the organization fit together"), but had a moderately high cross-loading (0.244) and did not have a strong conceptual relationship with the other items. Therefore EP2 was excluded from the second survey scale. The resultant variable is referred to as *experimentation and continuous improvement*. The revised survey scales are presented in Table 21.

Table 20. Pattern Matrix for Work Area Characteristic Survey Scales

	Component	
	1	2
STEW1	**0.973**	-0.152
STEW3	**0.952**	-0.119
STEW2	**0.835**	
EP1	**0.817**	
INT2	**0.801**	
INT3	**0.717**	0.194
EP3	**0.581**	0.250
KCI1	**0.561**	0.284
INT1	0.558	0.361
KCI3	0.423	0.277
EXPER3		**0.938**
EXPER2		**0.907**
KCI4	0.200	**0.718**
EP2	0.244	0.678
KCI2	0.291	**0.555**
Initial Eigenvalue	9.47	0.98
Percentage of Variance Explained	63.16	6.56

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
a. Rotation converged in 4 iterations.

Table 21. Revised Work Area Characteristics Survey Scales

Scale	Revised Item List

Experimentation and Continuous Improvement	EXPER2: Work area employees try out new things by applying them in practice.
	EXPER3: Work area employees test new ideas to help themselves learn.
	KCI2: Work area employees understand how continuous improvement can be applied to Work area.
	KCI4: Work area employees believe they have a role in continuous improvement in Work area
Learning and Stewardship	EP1: Work area employees understand how their work fits into the "bigger picture" of the organization.
	INT2: Work area employees ask each other for help when they need assistance.
	INT3: Work area employees freely share information with one another.
	STEW1: Work area employees feel a shared sense of responsibility for the work they do.
	STEW2: Work area employees feel a sense of accountability for the work they do.
	STEW3: Work area employees want to do what is best for the organization.
	EP3: Work area employees understand how their work relates to that of other parts of the organization.

3.5.4 EFA of Post-Event Characteristics Survey Scales

The pattern matrix for the Post-Event Characteristic survey scales is provided in Table 22. The results show that three of the *improvement culture* items loaded onto a single component that had an initial eigenvalue of 8.72 (41.53% of total variance). These items, ICulture6, ICulture7, and ICulture8, relate to the extent to which management supports and champions efforts to support improvement. Five of the *performance review* items loaded together to the second component that had an initial eigenvalue of 2.61 (12.43% of total variance). These items, PR1, PR2, PR4, PR5, and PR7, relate to measurement and evaluation of Kaizen event results. Five of the proposed *institutionalizing change* items, IChange1, IChange2, IChange3, IChange4, IChange5, along with one *performance review* item (PR3: "The Kaizen event team meeting as a whole to review progress and/or develop follow-up strategies for the Kaizen event.") loaded to the third component (initial eigenvalue of 1.47 and 7.00% of total variance). Collectively, these items relate work area employee and Kaizen event team member activities to continuously improve the work area through training, completion of action items, and documenting changes to work methods. The analysis also reveals the emergence of a fourth construct, named *avoiding blame* (initial eigenvalue of 2.03 and 9.66% of total variance). *Avoiding blame* includes the ICulture3

and ICulture4 items, which measure the extent to which blame and negativity are avoided. This construct relates to the extent to which rewards are allocated to support the institutionalization of change (Cummings and Worley, 1997), albeit the concepts have a reverse conceptual relationship. The linguistic construction of these items (i.e., identical wording at the beginning of the items, "Avoiding blame or negativity") further explains why these items loaded together.

Five items did not load cleanly to a single component. ICulture1 ("Rewarding or recognizing Kaizen event team members for their contributions") and IChange6 ("Providing work area employees with freedom to make changes to work area") had primary loadings onto a fifth component (initial eigenvalue = 1.23 and 5.85% of total variance) but had high cross-loadings on *institutionalizing change*. ICulture2 ("Rewarding or recognizing work area employees (not only those on the Kaizen event team) for progress on sustaining changes or completing action items from Kaizen event") loaded to *performance review* but had a high cross-loading on the fifth component. PR6 ("Meetings with work area management about Kaizen event progress or follow-up") loaded to *performance review* but had a high cross-loading on *institutionalizing change and* the fifth component. ICulture5 ("Work area management encouraging work area employees to apply continuous improvement knowledge and skills") loaded to *improvement culture* but had a high cross-loading on *institutionalizing change* and the fifth component. Collectively, these items appear to represent management activities or actions that may encourage work area employees to contribute to the work area in various ways, including granting freedom to make changes, apply continuous improvement, and providing rewards and recognition. However, the items are also conceptually related to the other constructs and therefore do not represent a unique contribution to a single variable. Therefore, these items are excluded from further analysis and Table 23 presents the revised survey scales.

Table 22. Pattern Matrix for Post-Event Characteristics

	Component				
	1	2	3	4	5
ICulture8				-0.730	
ICulture7				-0.881	
ICulture6				-0.901	
ICulture3			0.952		
ICulture4			0.947		
PR2		-0.753			

PR4		**-0.778**			
PR1		**-0.789**			0.260
PR5		**-0.824**			
PR7		**-0.854**			
IChange1	**0.833**				
PR3	**0.800**				
IChange5	**0.741**				
IChange4	**0.705**				
IChange2	**0.672**				
IChange3	**0.601**				
ICulture2		-0.589			0.303
ICulture1	0.392				0.788
IChange6	0.379			-0.306	-0.580
PR6	0.320	-0.595			-0.266
ICulture5	0.253			-0.704	-0.319
Initial Eigenvalue	8.72	2.61	2.03	1.47	1.23
Percentage of Variance Explained	41.53	12.43	9.66	7.00	5.85

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
a. Rotation converged in 14 iterations.

Table 23. Revised Post-Event Characteristic Survey Scales

Scale	Revised Item List
Institutionalizing Change	IChange1: Formal documentation of follow-up action items (e.g., through a Kaizen newspaper) from the Kaizen event. IChange2: Individual team members working on follow-up action items from the Kaizen event. IChange3: Training work area employees in new work methods and processes from the Kaizen event. IChange4: Updating work method and process documentation (e.g., standard work charts, formal job descriptions, etc.) for changes made due to the Kaizen event. IChange5: Involving work area employees (not on the Kaizen event team) in follow-up and completion of action items from the event. PR3: The Kaizen event team meeting as a whole to review progress and/or develop follow-up strategies for the Kaizen event.
Avoiding Blame	ICulture3: Avoiding blame or negativity when changes are made, but results are different than expected. ICulture4: Avoiding blame or negativity when team goals are not achieved.

Improvement Culture	ICulture6: Work area management supporting the use of Kaizen events in the organization. ICulture7: Work area management championing the value of continuous improvement. ICulture8: Work area management allowing work area employees time to work on continuous improvement activities.
Performance Review	PR1: Regularly reviewing performance data related to Kaizen event goals. PR2: Conducting regular audits on changes made due to the Kaizen event. PR4: Meetings with higher-level management about Kaizen event progress or follow-up. PR5: Meetings with Kaizen coordinator or facilitator about Kaizen event progress or follow-up. PR7: Informing higher-level management of issues with follow-up and sustaining results from the Kaizen event.

3.5.5 Data Reduction Methods of T1 Objective Work Area Characteristics

As presented in Section 3.3.3, the present research also includes Work Area Characteristics that operationalized changes in management's participation in Kaizen events, employee and management turnover, and changes related to the production system. In order to analyze the underlying relationships that are expected to exist between the objective Work Area Characteristics, a data reduction method known as nonlinear principal components analysis (PCA) was used. In nonlinear PCA, the input variables can have mixed optimal scaling levels and the relationships among observed variables are not assumed to be linear (Meulman and Heiser, 2005). As explained further by Linting et al. (2007), nonlinear PCA is

"[t]he nonlinear equivalent of standard PCA and reduces the observed variables to a number of uncorrelated principal components. The most important advantages of nonlinear over linear PCA are that it incorporates nominal and ordinal variables and that it can handle and discover nonlinear relationships between variables (p. 336)…The nonlinear PCA solution is not derived from the correlation matrix but iteratively computed from the data itself, using the optimal scaling process to quantify the variables according to their analysis level [nominal, ordinal, or numerical]. The objective of optimal scaling is to optimize the properties of the correlation matrix of the quantified variables (p. 338)."

In the present research, nominal, ordinal, and numerical (i.e., interval or ratio) objective Work Area Characteristics are considered for analysis. In nonlinear PCA, the nominal data requirement is that cases that scored the same category on the variable should also obtain the same quantified value. The ordinal data requirement is that each category quantification should be less than or equal to the quantification for the category that has a higher rank number in the original data. Finally, the numeric data must be ordered correctly and must also maintain the original relative spacing of the categories in the optimal quantifications, which can be achieved by standardizing the variable (Linting et al., 2007).

CATPCA is an analysis method within SPSS that performs nonlinear PCA on a set of variables. Similar to PCA, the resultant dimensions of CATPCA correspond to components and object scores correspond to component scores (Meulman and Heiser, 2005). Before executing CATPCA, three analysis options must be specified. First, the analysis level of each input variable is specified (e.g., nominal, ordinal, or numerical). Next, the numerical data, particularly for continuous variables that contain noninteger values, are discretized using the multiplying method which maintains the distributional properties as closely as possible by transforming the real-valued variable into a discrete variable containing integers (Meulman et al., 2004). CATPCA performs this transformation by multiplying the standardized values of the continuous, fractional-value variable by 10, rounds the value, and add a value such that the lowest value is 1 (because values less than 1 in CATPCA are considered missing) (Meulman and Heiser, 2005). Finally, the missing values are treated passively such that in optimizing the quantification of a variable, only objects with nonmissing values on the variable are involved contribute to the solution (Meulman and Heiser, 2005). Passive treatment differs from pairwise deletion in that the latter deletes pairs of values in pairwise computations, whereas passive treatment preserves all information (Linting et al., 2007). It should be noted that one of the drawbacks to the passive treatment method is that "Because objects have a different number of observations, the weighted mean of the object scores is now equal to 0, and because the mean itself is not 0, various optimality properties of nonlinear PCA are no longer valid. The maximum/minimum value of the component loadings is no longer equal to 1.0 and -1.0, and therefore a component loading can no longer be interpreted as a correlation" (Meulman et al., 2004, p. 64). This drawback should not be considered a severe limitation of passive treatment but simply a caveat that should be considered when interpreting results.

CATPCA object scores can be used in further analysis. Alternatively, the component loadings can be used to inform which variables can be combined to form factors for use in further analysis (e.g., Santos et al., 2008). The latter method will be used in the present research. Factors are retained based on satisfaction of Keiser criterion, i.e., eigenvalues greater than or equal to 1.0 (Meulman and Heiser, 2005). The reliability of the each resultant dimension is also assessed, with Cronbach's Alpha values greater than or equal to 0.6 representing acceptable reliability (DeVellis, 1991). Finally, component loadings greater than or equal to 0.4 are considered significant (Meulman and Heiser, 2005).

3.5.6 CATPCA of Objective Work Area Characteristics

The model summary, including the reliability measures and eigenvalues, and the component loadings for each dimension are provided in Table 24. While the eigenvalues of all three proposed dimensions are greater than 1.0, the Cronbach's alpha of dimensions two and three are less than 0.60. The reliability of the third dimension is markedly lower than 0.60 (0.32), suggesting that the dimension may not be suitable for further analysis. The component loadings show that the first dimension corresponds primarily to *management Kaizen event participation*. *Management change* had a moderately high loading to the first dimension (0.56), but had a much higher loading to the third dimension. It is conceptually logical that *management Kaizen event participation* and *management change* may be statistically related as they both refer to the work area management. However, the high loading of *management change* to the third dimension suggests that it may be more appropriate to consider *management Kaizen event participation* and *management change* as two separate variables.

The second dimension corresponds primarily to the variables *volume change*, *equipment change*, and *product mix change*. While *product mix change* did have a high cross-loading with dimension three, it was retained in the second dimension because conceptually, *product mix change* related closely to *volume change* and *equipment change*, i.e., the three variables relate to changes to the work area production processes. The number of "yes" responses across the three variables, referred to as *production system changes,* is used in further analysis.

Finally, there was not support for the proposed combination of *management change* and *employee change* as presented in Section 3.3.3. *Employee change* had a moderately high

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primary loading to the second dimension (0.48), which is higher than the suggested 0.40 threshold of significance (Meulman and Heiser, 2005). However, there is not conceptual support for combining *employee change* with *volume change*, *equipment change*, and *product mix change* because *employee change* refers to workforce changes while the other variables refer to work area production system changes. Therefore, *employee change* is included in the research model as a separate variable and is not combined with any other Work Area Characteristics.

Following the CATPCA, the previous operationalization of *management Kaizen event participation* as a nominal, single variable may make interpretation of regression findings regarding the potential role of the variable in sustaining Kaizen event outcomes difficult. This is because the case in which *management Kaizen event participation* = 1 and the case where *management Kaizen event participation* = 2 do not have a logical order such that one case would be preferable (See Table 16).

Therefore, *management Kaizen event participation* was converted into two dummy variables. The case in which *management Kaizen event participation* =0 (Table 16) did not appear in the dataset. (The case in which *management Kaizen event participation* =3 (Table 16) occurred in 52 of the 65 observed events. This means that, in the majority of the cases, current management had participated in KE at time of event, and current management had also participated since the observed Kaizen event. This category is omitted as the baseline group because it accounts for the largest number of cases (Field, 2009). The case in which *management Kaizen event participation* = 1 (Table 16) occurred in 1 of the 65 observed events and is now referred to as *management Kaizen event participation at T0*. The case in which *management Kaizen event participation* = 2 (Table 16) occurred in 8 of the 65 observed events and is now referred to as *management Kaizen event participation at T1*. The revised variables are presented in Table 25.

Table 24. CATPCA Objective Work Area Characteristics Component Loadings and Model Summary

Component Loadings	Dimension			
	1	2	3	
Volume Change	-0.053	**0.925**	-0.023	
Management Change	0.561	-0.298	**0.936**	

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	1	2	3	
Employee Change	0.146	0.418	-0.155	
Product Mix Change	0.132	**0.541**	0.493	
Management Kaizen Event Participation	**1.334**	0.039	-0.432	
Equipment Change	0.045	**0.699**	0.165	
Model Summary	Dimension			
	1	2	3	Total
Cronbach's Alpha	0.64	0.57	0.32	0.98[a]
Variance Accounted For Total (Eigenvalue)	2.14	1.90	1.36	5.40

Variable Principal Normalization.

a. Total Cronbach's Alpha is based on the total Eigenvalue.

Table 25. Revised Objective Work Area Characteristics

Proposed Factor	Input Data
Management Kaizen event Participation at T0	Binary dummy variable PEIS Questions: Have the current managers <u>all</u> participated in <u>at least one</u> Kaizen event? (1=yes, 2=no) At the time of the Kaizen event, had work area managers <u>all</u> participated in <u>at least one</u> Kaizen event? (1=yes, 2=no) *Management Kaizen event Participation at T0*= 1 when current management had participated in at least one Kaizen event at the time of the observed Kaizen event AND current management had NOT participated in at least one Kaizen event since the observed Kaizen event Otherwise, *Management Kaizen event Participation at T0*= 0
Management Kaizen event Participation at T1	Binary dummy variable PEIS Questions: • Have the current managers <u>all</u> participated in <u>at least one</u> Kaizen event? (1=yes, 2=no) • At the time of the Kaizen event, had work area managers <u>all</u> participated in <u>at least one</u> Kaizen event? (1=yes, 2=no) *Management Kaizen event Participation at T1*= 1 when current management had NOT participated in at least one Kaizen event at the time of the observed Kaizen event AND current management had participated in at least one Kaizen event since the observed Kaizen event Otherwise, *Management Kaizen event Participation at T1*= 0
Management Change	Binomial variable PEIS Question:

	Has work area management changed since the Kaizen event? (1=yes, 2=no)
Employee Change	Continuous variable PEIS Questions: • The number of current employees in the work area that were working in the work area at the time of the Kaizen event • The number of current employees in the work area *Employee Change =* 'The number of current employees in the work area that were working in the work area at the time of the Kaizen event' divided by 'The number of current employees in the work area'
Production System Changes	Polynomial variable PEIS Questions: • Have there been any major equipment changes in the work area since the Kaizen event? (1=yes, 2=no) • Have there been any major volume changes in the work area since the Kaizen event? (1=yes, 2=no) • Have there been any major product mix changes in the work area since the Kaizen event? (1=yes, 2=no) Data for Analysis: • *Production System Changes*= The number of "yes" responses across the three questions (ranges from zero to three)

3.6 Reliability of Revised Scales

Once the factors have been extracted to form the revised survey constructs, the reliability of the constructs must be assessed. A measure that yields consistent results is considered reliable (Fowler, 1993). The key reliability perspective to monitor in survey research is the internal consistency among responses to the items of a given survey construct. Cronbach's Alpha is commonly used to measure the *internal consistency* of interval, multi-item scales.   The Cronbach's alpha values for all of the constructs were higher than the commonly recommended threshold of 0.70 for survey scales (Nunnally, 1978). The alpha values of the survey scales are presented in Table 26.

Table 26. Cronbach's Alpha Values for Revised Survey Scales

	Scale	Cronbach's Alpha	Largest Increase if Item Deleted
Kaizen Event Characteristics	*Goal Clarity*	0.88	0.88 (GC2)
	Goal Difficulty	0.81	No increase
	Management Support	0.78	0.83 (MS5)
Post Event	*Institutionalizing Change*	0.88	No increase

Characteristics	Improvement Culture	0.80	0.85 (ICulture8)
	Performance Review	0.88	No increase
	Avoiding Blame	0.95	N/A
Work Area Characteristics	Learning and Stewardship	0.95	No increase
	Experimentation and Continuous Improvement	0.90	No increase
Sustainability Outcomes	Impact on Area	0.94	No increase
	Work Area Attitude and Commitment	0.94	No increase

3.7 Descriptive Statistics of Resultant Variables

Following the reliability analysis, scale averages for each individual respondent in the data set were calculated using the revised scales. In addition, the averages of the other items in the scale were substituted for missing values in cases where a respondent was missing only one item in a given scale. This approach has been demonstrated to be superior to other approaches for replacing missing data, such as pairwise or listwise deletion because it minimizes bias while maintaining power (Roth et al., 1999). Finally, the resultant survey scales and continuous variables were assessed to determine their statistical moments, distributional properties, and the collinearity of the independent variables.

The variables *goal difficulty, goal clarity, team functional heterogeneity, management support, institutionalizing change* appear to be relatively normally distributed and formal tests of normality were not rejected for the aggregate measures. While formal tests of normality were rejected for *work area attitude and commitment, impact on area sustainability, improvement culture*, *performance review, avoiding blame, learning and stewardship, experimentation and continuous improvement, production system changes,* and *management change,* they appeared to be relatively normally distributed and only demonstrated mild departures from normality.

The variables *result sustainability, work area routineness*, and *employee change* appeared to be more severely skewed and formal tests of normality were rejected. *Result sustainability* appeared to be negatively skewed and formal tests of normality were rejected, most likely due to three low extreme outliers. *Work area routineness* appeared to be negatively skewed and formal tests of normality were rejected, most likely due to two low extreme outliers. *Employee change* appeared to be negatively skewed and formal tests of normality were rejected, most likely due to two low extreme outliers. However, these variables had an absolute skewness value less than 2.0

which is the commonly applied univariate skewness threshold to conduct statistical analysis (e.g., DeCarlo, 1997).

Goal sustainability appeared to be positively skewed and formal tests of normality were rejected. *Goal sustainability* appeared to be positively skewed and also rejected formal tests of normality. A logarithmic (base ten) transformation improved the symmetry of the distribution, although formal normality tests were still rejected and the skewness value was still greater than 2.0 (2.820). Therefore, goal sustainability was explored but with the caveat that the distribution may influence the findings. For this transformed variable, a value of 0.01 was added to the original value in order to calculate the transformation for teams that had an original *goal sustainability* value of 0% because the log of zero is undefined.

The variables *management Kaizen event participation at T0* and *management Kaizen event participation at T1* were expected to be highly skewed because they are binary dummy variables; thus, they purposefully represent cases that were less frequently observed in the data and are presented as the frequency that occurs in each category, 0 and 1.

In summary, the majority of continuous variables appeared to be relatively normally distributed and logarithmic (base ten) transformed variable will be used in further analysis for *goal sustainability*. Appendix F includes a summary of the descriptive statistics of the final set of study variables.

Finally, before the Sustainability Outcome models were analyzed, the collinearity of the resultant independent variables was assessed. In order to assess collinearity, the variance inflation factor (VIF) was calculated to measure the extent to which a given predictor covaries with all the other predictors in the model. The VIF values were calculated using the PROC REG procedure in SAS 9.2. Following the VIF "rule of thumb," an individual VIF value of 10.0 or greater indicates a problem with multicollinearity, as does an average VIF substantially greater than 3.0 (Neter et al., 1996). In the present research, the maximum observed VIF was less than 5.0, and the average VIF was less than 3.0 (Table 26). Thus, it appears that multicollinearity is not severe. Figure 9 illustrates the final proposed research model to be used in further analysis.

Table 27**. Variance Inflation Factor Values for all Independent Variables**

Variable	VIF
Goal Clarity	2.23
Goal Difficulty	2.24

Team Functional Heterogeneity	1.54
Management Support	1.67
Work Area Routineness	2.69
Institutionalizing Change	2.28
Improvement Culture	1.57
Performance Review	3.09
Avoiding Blame	2.24
Management Change	1.91
Production System Changes	1.87
Management Kaizen Event Participation at T0	1.67
Management Kaizen Event Participation at T1	1.41
Employee Change	1.68
Learning and Stewardship	4.26
Experimentation and Continuous Improvement	3.48
Average	**2.24**

Based on the literature review (Chapter 2) and the methods used to collect data and prepare the data for analysis (Chapter 3), the revised research model of Kaizen event outcome sustainability is presented (Figure 9). This model illustrates the variables and relationships that were tested against the Sustainability Outcomes in the next chapter, Chapter 4.

Work Area Characteristics
Work Area Routineness
Learning and Stewardship
Experimentation and Continuous Improvement
Management Kaizen Event Participation at T0
Management Kaizen Event Participation at T1
Management Change
Employee Change
Production System Changes

Kaizen Event Characteristics
Goal Clarity
Goal Difficulty
Team Functional Heterogeneity
Management Support

Sustainability Processes
Institutionalizing Change
Improvement Culture
Performance Review
Avoiding Blame

Sustainability Outcomes
Result Sustainability
Goal Sustainability
Impact on Area Sustainability
Work Area Attitude and Commitment

Figure 9. Revised Operational Research Model

CHAPTER 4: RESULTS

The study hypotheses to be tested in this research are:

- H1. Kaizen Event Characteristics will be positively related to Sustainability Outcomes at the team level.

- H2. Work Area Characteristics will be positively related to Sustainability Outcomes at the team level.

- H3. Post-Event Characteristics will be positively related to Sustainability Outcomes at the team level.

- H4. Post-Event Characteristics will partially mediate the relationship of Kaizen Event Characteristics and Sustainability Outcomes

- H5: Post-Event Characteristics will partially mediate the relationship of Work Area Characteristics and Sustainability Outcomes

The modeling process used to test the study hypotheses was as follows:

- To test H1, H2, and H3, regression analyses were performed using generalized estimating equations (GEE) to account for (potentially) correlated residuals within organizations. The regression models were used to determine which Kaizen Event Characteristics, Work Area Characteristics, and Post-Event Characteristics were significantly related to each Sustainability Outcome.

- To test H4 and H5, mediation analyses were conducted. The purpose of the mediation analyses was to determine whether any Post-Event Characteristics mediated the relationship between either the Kaizen Event Characteristics or Work Area Characteristics and each Sustainability Outcome. Finding such a relationship would be consistent with the mediation hypothesis that Kaizen Event Characteristics or Work Area Characteristics had an indirect effect on a Sustainability Outcome through the Work Area Characteristics.

The following section (4.1) presents an overview of the analysis methods used to test the hypotheses.

4.1 Overview of Methods Used to Test Study Hypotheses

The current research includes nested data, i.e., teams within organizations. Thus, it is likely that the observations of teams within a given organization may be correlated due to

contextual factors. The degree to which responses from individuals in the same group are influenced by, depend on, or cluster by group, should be accounted for in order to acknowledge commonalities in an organization that may cause observations within organizations to be more similar than the total dataset (Bliese, 2000). Multilevel models are able to correct for these clustering effects in the calculation of standard errors to avoid spuriously significant results (Hox, 2002). There are various multilevel models, including 'hierarchical linear model', 'variance component model', and 'random coefficient model' that are collectively referred to as 'multilevel regression models.' Multilevel regression models can differ based on a researcher's choice of estimation method. Each estimation method differs in the specific calculations of the regression coefficient values and variance components. Also, opinions on how large a sample size should be for a modeling approach differs among multilevel regression modeling experts. In phase one of the OSU-VT research, extensive exploration of various multilevel regression methods was conducted, and concluded that generalized estimating equations was the ideal method to analyze the nested data while accounting for the smaller sample size (Farris, 2006; Farris et al., 2009). For example, hierarchical linear modeling (Raudenbush and Byrk, 2002) models both the fixed effects (intercepts and slopes) across groups and the random effects, including the residual variance in intercepts across groups, the residual variance in slopes across groups, and individual-level residual variance within-groups (Bliese and Hanges, 2004). However, researchers suggest that at least 10 observations per predictor per level are needed for analysis (Raudenbush and Byrk, 2002). The phase one research and the present research do not meet this sufficient sample size threshold. Therefore, HLM was not considered appropriate for the present research analysis.

The present research also considered the use of structural equations modeling (SEM) for hypothesis testing. However, SEM requires balanced "time-structured" data within subpopulations (Raudenbush and Byrk, 2002) and a large sample size of five to ten cases per estimated model parameter is historically recommended (e.g., Bentler and Chou, 1987). While recent research finds that certain SEM estimation methods, especially the k-factor-corrected Satorra-Bentler scaled test statistic (T_{SB1-k}) which is designed specifically to handle non-normal data, allow an observation to estimated parameter ratio of 2:1 for various model complexities and sample sizes between 50 and 100 (Nevitt and Hancock, 2004), the statistic can be biased (Kolenikov and Bollen, 2008), even when the data is only slightly non-normal. Based on the

sample size concerns and the fact that the there was not balanced time intervals in the data, SEM was not considered appropriate for the present research analysis.

In summary, generalized estimating equations (GEE) was found to be the most appropriate primary estimation procedure analyses to account for the nested data and smaller sample size in the current sample. The following Sections further describe the methods used to test the study hypotheses.

4.1.1 Testing Direct Effects

Exploratory regression models using generalized estimating equations (GEE) were used to determine the Kaizen Event Characteristics, Work Area Characteristics, and Post-Event Characteristics that had the most significant effects on Sustainability Outcomes. Introduced by Liang and Zeger (1986), the GEE methodology provides a method of analyzing correlated data, including longitudinal studies that examine repeated subjects and measures (Hardin and Hilbe, 2003) and with clustered or multilevel datasets in which measurements are taken on subjects who share a common characteristic (Hox, 2002). The present research uses GEE to account for clustered effects.

When using GEE, there are several modeling decisions or specifications that must be made. First, specification of the dependent variable distribution and also the link function, or how the dependent variable relates to the predictor variables, is determined. GEE allows for several model combinations. Because the dependent variables exhibited relatively continuous distributions, all dependent variables were initially modeled as normal and an identity link function was used (Garson, 2009).

Next, there are several types of working correlation matrices that can be used to account for the clustered data. The following discusses four common options as presented by Hardin and Hilbe (2003) and Garson (2009). Use of an independent correlation matrix assumes measurements for the repeated measure are uncorrelated. The initial structure of the correlation matrix of within-subjects variables is assumed by the estimation algorithm to start as an identity matrix, meaning that a variable is correlated with itself at any given time but is not correlated with other variables. However, this assumption is incorrect for the present research, i.e., the present research assumes the measures are correlated. Use of the unstructured correlation matrix assumes a completely general pairwise correlation matrix, i.e., the correlation estimates are

estimated without constraints, which may be ideal when assumptions cannot be made about the correlations between cases. However, the present research does not anticipate that the unique pairwise correlations would hold across clusters given the fact that the observations are not equally spaced or ordered in any way. An autoregressive correlation matrix assumes time series data with equal time intervals and assumes that correlation diminishes exponentially with time. However, the data collection time intervals between teams within organizations (clusters) in the present research were not equal. The present research uses an exchangeable correlation matrix to model the association between nested observations in the data, which assumes equal correlation between all observations within a given cluster, i.e., teams within a given organization. The estimation algorithm assumes 1's on the diagonal and equal correlation for all off-diagonal elements. The exchangeable correlation matrix is the most appropriate for the present research because of the lack of natural ordering of the observations and the expected presence of the correlations of teams within organizations.

Finally, GEE reports two standard error estimates: robust or "empirical" standard error estimates and "model-based" standard error estimates. Empirical standard error estimates use the actual variations in the cluster-level statistics and may be considered more reliable than the model-based standard error estimates in analysis with large sample sizes, i.e., greater than 20 clusters (Hanley et al., 2003; Garson, 2009). However, researchers note that empirical standard error estimates were developed for uncorrelated observations and the theoretical behavior of empirical standard error estimates with correlated data has received limited research attention (Hanley et al., 2003). The model based standard error estimates are based on the estimated exchangeable correlation matrix (Hanley et al., 2003) and tend to give more consistent estimates of covariance even when the working correlation matrix is misspecified (Garson, 2009). Given that the present research has a relatively small sample size at the organizational level (eight clusters) and that it utilizes the exchangeable correlation matrix, the model-based standard error estimates are used throughout this research.

The GEE modeling was executed using PROC GENMOD in SAS 9.2. Because of the exploratory nature of this research, several selection procedures were used to conduct the GEE modeling. First, a manual backward selection procedure using GEE was used. At each step in the selection procedure, if the p-value for one or more variables was greater than $\alpha=0.10/k$, where k is the number of parameters in the model (i.e., the number of predictor variables plus

one), the variable with the largest p-value was removed. This procedure was repeated until all remaining variables were significant at the α=0.10/k level.

Next, a hierarchical procedure tested the significance of the Post-Event Characteristics and subsequently tested the significance of the Kaizen Event and Work Area Characteristics. This hierarchical structure was used to account for the fact that the research model hypothesizes that the Post-Event Characteristics may mediate the relationship between the Kaizen Event Characteristics and Work Area Characteristics. In this hierarchical procedure, the Post-Event Characteristics were iteratively removed from the model if the p-value was greater than α=0.10/k. Next, the Kaizen Event and Work Area Characteristics were added to the exploratory analysis and were iteratively removed using the α=0.10/k criterion. However, the Post-Event Characteristics that were found to be significant at the first stage of the procedure were retained in the model until all Kaizen Event and Work Area Characteristics had been explored.

Ordinary least squares (OLS) regression modeling was also conducted using PROC REG in SAS 9.2. The research examined the OLS automated backward, stepwise, R^2, MAXR, and C_p selection procedures in order provide additional support for the GEE findings and explore different "good" sets of variables that may assist in the explanation of Sustainability Outcomes may not have been identified in the GEE manual backwards and hierarchical procedures.

Next, the resultant model fit was assessed through several statistics. First, the R^2 and adjusted R^2 values were used to assess the amount of variation that is accounted for in the model. The R^2 and adjusted R^2 values are automatically generated using the OLS procedures but the GEE R^2 and adjusted R^2 values were manually calculated as recommended by Hardin and Hilbe (2003). The GEE and OLS parameter estimates were observed to ensure that the values were similar. GEE and OLS parameter estimates are expected to be similar because both estimation methods are asymptotically unbiased and thus they both approach the same value. In addition, the sign of the GEE intraclass correlation coefficient was observed. A positive GEE intraclass correlation coefficient indicates that more variation may occur within clusters versus between clusters (organizations). A negative GEE intraclass correlation coefficient indicates that more variation may occur between clusters (organizations) versus within clusters. Finally, in order to detect serious errors of model specification, the model fit was examined via the following residual approaches: residual plots, partial regression plots, the Wald-Wolfowitz run test, and observation of the residual outliers (Field, 2009). The residual plots and partial regression plots

were assessed for departures from linearity. The Wald-Wolfowitz run test was used to assess whether or not there was a random pattern in the residuals (Chang, 2000). Observation of the residual outliers revealed was used to detect evidence of influential cases, i.e., cases that had an absolute value greater than 3.0.

4.1.2 Testing Mediating Effects

Mediation analysis was used to determine whether the Kaizen Event Characteristics or Work Area Characteristics had an indirect effect on the Sustainability Outcomes through the mediating Post-Event Characteristics *institutionalizing change, avoiding blame, improvement culture,* and *performance review*. A mediator is a variable that is in a causal sequence between two variables (MacKinnon et al., 2007) and mediation occurs when an input variable acts indirectly upon an outcome variable through a third, mediating process variable (Baron and Kenny, 1986). Because Kaizen Event Characteristics occur before any post-event activities can occur and because it appears as though Work Area Characteristics may influence the post-event activities that do occur in a work area, there appears to be support for the fact that Post-Event Characteristics may be in a "causal sequence" between the Kaizen Event and Work Area Characteristics and the Sustainability Outcomes. Furthermore, the structure of the institutionalization change theory model (e.g., Goodman and Dean, 1982), as well as the team effectiveness theory models (e.g., Cohen and Bailey, 1997) used to inform the first phase of the OSU-TV research (Farris, 2006), provide support for the use of mediation analysis to consider the relationship and additional information that the Post-Event Characteristics may provide in modeling Sustainability outcomes. Figure 10 presents the tested mediation relationships (MacKinnon et al., 2007). In short, the figure illustrates that the variables X may have a direct effect on the outcomes Y, but may also have an indirect effect through the mediation variable, Z.
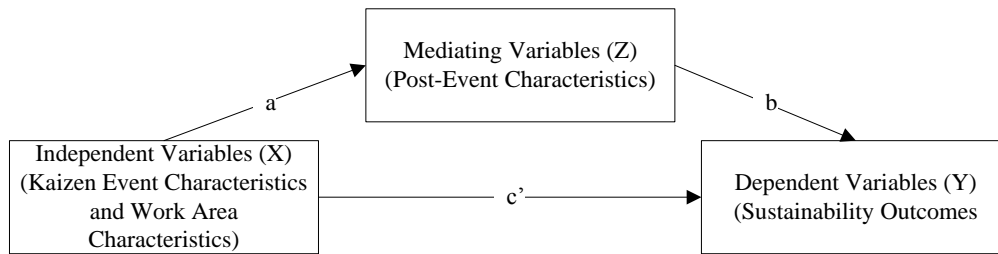
Figure 10. Mediation Analysis Model (adapted from MacKinnon et al., 2007)

GEE was also used to analyze the mediation relationships. A four step process was used to perform the mediation analysis (Judd and Kenny, 1981; Baron and Kenny, 1986; MacKinnon et al., 2000; Kenny, 2009); the first two steps are the primary mediation analysis testing and the last two steps test the robustness of the solution found in the primary mediation analysis testing.

The first two steps tested the three paths to evaluate each mediation hypothesis. Therefore an alpha level of $0.05/3 = 0.0167$ was adopted as the significance level for each path to preserve an overall 0.05 confidence level for the test (Kenny, 2009). The following describes the first two steps that were performed:

1. The mediating process variable (z) was separately regressed on each input variable individually (x) and the resulting coefficient (a) was tested for significance.

2. If a significant relationship was demonstrated in step one, the outcome variable (y) was regressed on both the input variable (x) and the mediating process variable (z), and the resulting regression coefficients were tested for significance. A significant regression coefficient (b) for the mediating process variable (z) is necessary for the demonstration of a mediation effect. The regression coefficient (c') for input variable (x) can be either significant (partial mediation) or non-significant (full mediation).

The following describes the last two steps that were used to test the robustness of each mediation solution:

3. After the two preceding steps were accomplished for all nine input variables, the mediating process variable (z) was simultaneously regressed on all the input variables (x_i) significant in step one. This step was performed to confirm whether each input variable (x_i) was a significant unique predictor of the mediator (z), after controlling for the other input variables.

4. In addition, the direct relationship between each input variable (x) and the outcome (y) was tested for significance. A significant direct relationship further supports the mediation

hypothesis, but is not strictly necessary for demonstrating mediation hypothesis to hold (MacKinnon et al., 2000).

4.2 Work Area Attitude and Commitment Model

4.2.1 Identification of Direct Predictors of Work Area Attitude and Commitment

The manual backward selection procedure and the hierarchical selection procedure, both using GEE model-based standard error estimates, converged upon a two predictor model: *performance review* (β= 0.193, p=0.003) and *experimentation and continuous improvement* (β= 0.389, p=0.002). This solution was the best two variable model found by the R^2, MAXR, and C_p OLS selection procedures (ADJRSQ did not yield a two variable model as the procedure only yields solutions with the highest ADJRSQ).

Using the backward and stepwise OLS regression procedures, *goal clarity, management Kaizen event participation at T1, institutionalizing change, performance review,* and *experimentation and continuous improvement* were found to be significant at the 0.05 level. However, this solution was not significant using the GEE model-based standard error estimates because *goal clarity* (β= 0.242, p=0.126), *management Kaizen event participation at T1* (β= -0.098, p=0.645), and *institutionalizing change* (β= -0.049, p=0.513) were not significant. At the adjusted α level (.1/7=0.0143), the variables *performance review, experimentation and continuous improvement,* and *institutionalizing change* are still significant in the OLS backward and stepwise regression results. This solution was the best three variable model found by the R^2, MAXR, and C_p selection procedures (ADJRSQ also did not yield a three variable solution). This three variable model, however, is not significant using the GEE model-based standard error estimates because *institutionalizing change* was not significant (β= -0.049, p=0.513). Based on these analyses, the two variable solution including *performance review* and *experimentation and continuous improvement* was adopted (Table 28).

Table 28. Regression Model of Work Area Attitude and Commitment

	GEE β	SE GEE β	α GEE	OLS β	SE OLS β	α OLS
Intercept	2.044	0.463	<.0001	1.782	0.443	0.000
Performance Review	0.193	0.064	0.003	0.219	0.066	0.002

Experimentation and Continuous Improvement	0.389	0.104	0.000	0.442	0.108	0.000
OLS R^2 = 0.419, OLS R_a^2 = 0.399, F2,61 = 21.99***						
GEE R^2 =0.419, GEE R_a^2 = 0.399, ρ= 0.264						

As expected, the regression coefficients are similar for the GEE estimation versus the OLS estimation. However, the observed intraclass correlation reported by the GEE procedure was 0.264. Because the observed intraclass correlation was positive, more variation occurs within clusters versus between clusters (organizations), providing additional support for the use of the exchangeable matrix for the GEE analysis to study this outcome.

Finally, in order to determine whether or not serious errors of model specification may exist, the model fit was examined via residual analysis. The residual plots and partial regression plots did not indicate departures from linearity. Observation of the residual outliers revealed that the largest absolute value was 1.6791, indicating that there was no strong evidence of influential cases. However, the Wald-Wolfowitz run test indicated that the residuals did not exhibit a random pattern (p=0.001). This suggests that the current model may need additional modification to account for the underlying data structure (Chang, 2000). The present version of the *work area attitude and commitment* model was used to explore the mediation hypotheses for the outcome variable, but further exploration of the model was conducted in post-hoc analysis, where the Wald-Wolfowitz test was reexamined (see Section 4.6.1).

4.2.2 Mediation Analysis to Identify Indirect Predictors of Work Area Attitude and Commitment
Mediation analysis was used to determine whether any input factors, i.e., the Kaizen Event Characteristics or Work Area Characteristics, had an indirect effect on *work area attitude and commitment* through the mediating process factors, i.e., the Post-Event Characteristics. The three step approach explained in Section 4.1.2 was used to test the mediation hypotheses. Table 27 presents mediation results. Significant p-values at adjusted alpha levels are designated by an asterisk.

In step one, the mediating process variable was regressed on each input variable separately. *Performance review* was the only Post-Event Characteristic that was found to be significant in the previous direct effect analysis. Two input variables, *work area routineness* and *learning and stewardship* were significantly related to *performance review (*as indicated by

relationship a in Table 29). For step two, *work area attitude and commitment* was regressed each input variable and *performance review*. *Performance review* had a significant relationship with *work area attitude and commitment* while controlling separately for *work area routineness*, thus providing support for the mediation hypothesis (as indicated by relationship b in Table 27). Relationship c' was non-significant for *work area routineness*, which is consistent with a full mediation effect that *work area routineness* significantly affects *work area attitude and commitment*, but only indirectly through *performance review*.

      Performance review did not have a significant relationship at the 0.0167 level with *work area attitude and commitment* while controlling separately for *learning and stewardship* (as indicated by relationship b in Table 27). However, the p-value was fairly low (0.0295), providing marginal support for a mediation effect that *learning and stewardship* impacts *work area attitude and commitment* indirectly through *performance review*. In addition, relationship c' was significant for *learning and stewardship*, which is consistent with a partial mediation effect. When examining the relationship between *learning and stewardship* and *work area attitude and commitment* in post-hoc analysis, it was found that a direct effect exists when *experimentation and continuous improvement* is excluded from the model but is not a significant predictor when *experimentation and continuous improvement* is included. Therefore, partial mediation is not fully supported in the final model. However, the marginally-supported full mediation of *learning and stewardship* is retained in the model to emphasize the potential impact that *learning and stewardship* may have on *work area attitude and commitment* that may be explored in further research.

      For step 3, *performance review* was regressed simultaneously on *work area routineness* and *learning and stewardship*. Indicated by relationship a' in Table 27, both variables were clearly significant in this regression ($p < 0.05$), thus providing further support for the mediation hypothesis. For step 4, *work area attitude and commitment* was regressed separately on *work area routineness* and *learning and stewardship*. In considering the direct effects of the input variables on the outcome, only *learning and stewardship* had a significant direct effect at the 0.05 level. The p-value for *work area routineness* was very high (0.680).

      While some of the early research on mediation analysis required the relationship between the independent and dependent variable to be significant in order for mediation to hold (e.g., Baron and Kenny, 1986), more recent research from MacKinnon et al. (2000) notes that cases

where the statistical removal of a mediating variable could increase the magnitude of the relationship between the independent and dependent variable are called suppression effects; the following explanation is based on that work (MacKinnon et al., 2000). Suppression is evident in the case of *work area routineness* because its direct effect is negative (-0.030) and its and indirect effect is positive (0.095), which may be cancelling the significance of the direct effect. In this case, the suppressor effect could be explained either by the fact that *performance review* is a true mediating variable or a confounding variable that is accentuating the relationship because, for example, it helps to explain the variation in *work area routineness*. Because determining whether *performance review* is a true mediating or confounding variable can only be distinguished conceptually rather than statistically, having a significant direct relationship between the independent and dependent variable is not considered strictly necessary for a mediation hypothesis to hold (MacKinnon et al., 2000). In summary, *work area routineness* and *learning and stewardship* are presented as fully mediated variables in the model of *work area attitude and commitment*.

Table 29. Mediation Analysis Results for Work Area Attitude and Commitment

Step 1: y'= Performance Review, separate regression	Coef. (a)	S.E.	p-value			
Goal Clarity	0.190	0.311	0.5407			
Goal Difficulty	0.193	0.220	0.3809			
Team Functional Heterogeneity	0.184	0.866	0.8322			
Management Support	0.108	0.290	0.7094			
Work Area Routineness	0.353	0.138	0.0108*			
Management Change	0.052	0.262	0.8429			
Production System Changes	0.049	0.199	0.8050			
Management Kaizen Event Participation at T1	-0.283	0.388	0.4249			
Management Kaizen Event Participation at T0	-0.415	1.069	0.6981			
Employee Change Ratio	-0.698	0.837	0.4045			
Learning and Stewardship	0.636	0.187	0.0007*			
Experimentation and Continuous Improvement	0.324	0.194	0.0950			
Step 2: y'= Work Area Attitude and Commitment, separate regression	**Coef. (b)**	**SE**	**p-value**	**Coef. (c')**	**SE**	**p-value**
Performance Review	0.270	0.068	<.0001*			
Work Area Routineness				-0.130	0.082	0.1137
Performance Review	0.145	0.067	0.0295			
Learning and Stewardship				0.408	0.109	0.0002*

Step 3: y'= Performance Review, simultaneous regression	Coef. (a')	SE	p-value	
Work Area Routineness	0.383	0.132	0.0039*	
Learning and Stewardship	0.672	0.178	0.0002*	
Step 4: y'= Work Area Attitude and Commitment, separate regression	**Coef.**	**SE**	**p-value**	
Work Area Routineness	-0.030	0.073	0.6800	
Learning and Stewardship	0.500	0.096	<.0001*	
Mediation Analysis Results for Performance Review and Work Area Attitude and Commitment	**Total mediated effect (a*b)**		**Partial or Full**	
Work Area Routineness	0.095		Full	
Learning and Stewardship	0.092		Full	

4.3 Impact on Area Sustainability Model

4.3.1 Identification of Direct Predictors of Impact on Area Sustainability

The backward selection procedure and the hierarchical selection procedure, both using GEE model-based standard error estimates, converged upon a one predictor model, *avoiding blame* (β= 0.050, p=0.000). This was the third best one-variable model found by the OLS R^2 selection method and explained a small amount of the outcome variance (R^2=0.093). At the adjusted α level, the OLS backward regression procedure converged on a four-variable model that included *work area routineness, institutionalizing change, avoiding blame,* and *production system changes.* However, this solution was only the sixth best four-variable model found by the R^2 selection procedure, and the solution was not significant in the GEE model-based standard error estimates because only *avoiding blame* was significant at the 0.05 level. At the adjusted α level, the OLS stepwise regression procedure converged upon a two-variable model that included *work area routineness* and *avoiding blame,* which is the second best 2-variable model found by the R^2 selection procedure. However, this solution is not significant using the GEE model-based standard error estimates because *work area routineness* was not significant (p=0.215).

The backward OLS regression procedure converged upon an eight variable model at the 0.05 level that included *goal difficulty, management support, work area routineness, institutionalizing change, performance review, avoiding blame, management change*, and *production system changes*. This was the best eight-variable model found by the R^2, ADJRSQ, MAXR, and C_p selection procedures (R^2 = 0.576). The stepwise OLS regression procedure

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converged upon a five-variable solution at the 0.05 level that included *team functional heterogeneity, management support, work area routineness, avoiding blame,* and *production system changes.* This was the third best five-variable solution found by the R^2 selection procedure. However, neither solution was significant using the GEE model-based standard error estimates because *goal difficulty* (β= 0.036, p=0.432)*, work area routineness* (β= 0.062, p=0.0852)*, institutionalizing change* (β= 0.035, p=0.182), *performance review* (β= 0.002, p=0.933), *management change* (β= -0.092, p=0.143), and *production system changes* (β= 0.058, p=0.188) were not significant.

Next, a solution containing the variables found to be significant at the 0.05 level in both the automated OLS backward and the stepwise models, *management support, work area routineness, avoiding blame,* and *production system changes* was considered. However, variables using the GEE model-based standard error estimates were not significant as only *avoiding blame* was significant at the 0.05 level.

Various combinations of the variables that were significant at the 0.10 level in at least one of the modeling procedures were also explored. The four-variable solution containing *team functional heterogeneity, work area routineness, avoiding blame*, and *management Kaizen event participation-T1* was significant using the GEE model-based standard error estimates (Table 30). However, there are several concerns regarding the justification of this model. The variables are not significant at the adjusted alpha level, but at the 0.05 level. Also, this solution had only the fifth highest four-variable solution using the OLS R^2 selection procedure (R^2 = 0.376). Furthermore, the model was not identified directly through any of the structured selection procedures.

The issues with modeling *impact on area sustainability* may be caused by the fact that the variable is measured as a ratio of facilitator perspectives at T1 compared to team member perspective at T0. Using a ratio of different respondents to create a single measure may introduce an inaccuracy in the measure that cannot be accounted for in the regression model. Furthermore, because the modeling of *impact on area sustainability* did not appear to converge on a solution that could be fully supported by both the GEE and OLS regression techniques and had a relatively low R^2 value (GEE R^2 = 0.229), it was determined that the model of *impact on area sustainability* did not appear to be very satisfactory in explaining variation in the lasting

impact that the Kaizen event may have on a work area. Alternatively, the variable, *impact on area-T1* was explored.

Table 30. Regression Model of Impact on Area Sustainability

	GEE β	SE GEE	α GEE	OLS β	SE OLS	α OLS
Intercept	0.121	0.219	0.581	0.035	0.242	0.885
Team Functional Heterogeneity	0.365	0.153	0.017	0.399	0.163	0.017
Work Area Routineness	0.070	0.031	0.026	0.079	0.032	0.018
Avoiding Blame	0.072	0.015	<.0001	0.076	0.022	0.001
Management Kaizen Event Participation at T1	0.171	0.084	0.041	0.188	0.084	0.030
OLS R^2 = 0.231, OLS R_a^2 = 0.179, F4,59 = 4.43 ***						
GEE R^2 =0.229, GEE R_a^2 = 0.176, ρ= -0.055						

4.3.2 Identification of Direct Predictors of Impact on Area-T1

Because of the limited meaning that could be interpreted from the *impact on area sustainability* model, the *impact on area-T1* measure was explored. *Impact on area-T1* is a construct that measures facilitator or work area manager perceptions of the impact that the Kaizen event had on the work area as of T1 and includes the three survey scale items that comprised the numerator of the *impact on area sustainability* measure. In other words, instead of being measured as a ratio, *impact on area-T1* only includes the items related to the perceived impact on area that were collected using the PEIS. *Impact on area-T1* appeared to be relatively normally distributed and formal tests of normality were not rejected (max=1, min=6, mean=4.55, st.dev.= 1.038, skewness=-1.147).

The manual backward selection procedure and the hierarchical selection procedure, both using GEE model-based standard error estimates, converged upon a two predictor model: *work area routineness* (β= 0.310, p=0.015) and *avoiding blame* (β= 0.438, p < 0.001) which was also the best two variable model found by the R^2 and MAXR selection procedures (R^2= 0.2698). The C*p* and ADJRSQ procedures did not yield a two-variable solution. Interestingly, *work area routineness* and *avoiding blame* were also included in the model of *impact on area*

sustainability, but the variables are able to explain a slightly greater amount of variance in the model of *impact on area-T1*.

Using the backward and stepwise OLS regression procedures, *work area routineness, avoiding blame,* and *production system changes* were found to be significant at the 0.05 level. The variable *institutionalizing change* was also included in the resultant models, but at p=0.07. This solution was the best four-variable solution found by the R^2, MAXR, and Cp selection procedures (ADJRSQ also did not yield a three-variable solution). However, this four-variable solution was not significant using the GEE model-based standard error estimates because *production system changes* (β= 0.159, p=0.369)*,* and *institutionalizing change* (β= 0.169, p=0.082) were not significant. Based on these analyses, the two-variable solution including *work area routineness* and *avoiding blame* was adopted (Table 31).

Table 31. Regression Model of Impact on Area-T1

	GEE β	SE GEE β	α GEE	OLSβ	SE OLSβ	α OLS
Intercept	1.344	0.724	0.063	1.489	0.829	0.078
Work Area Routineness	0.310	0.127	0.015	0.298	0.132	0.028
Avoiding Blame	0.438	0.059	<.0001	0.406	0.091	<.0001
OLS R^2 = 0.253, OLS R_a^2 = 0.228, F2,61 = 10.32 ***						
GEE R^2 =0.254, GEE R_a^2 =0.229, ρ= -0.055						

The GEE and OLS model parameters are similar. Also, the observed intraclass correlation reported by the GEE procedure was -0.055. Because the observed intraclass correlation was negative, more variation occurs between clusters (organizations) than within clusters (organizations). However, it should also be noted that the intraclass correlation may not be significantly different from zero. Finally, the residual analysis did not detect serious errors of model specification. The residual plots and partial regression plots did not indicate departures from linearity. The Wald-Wolfowitz run test was not significant, indicating a random pattern in the residuals. Observation of the residual outliers revealed that the largest absolute value was 2.510, indicating that there at least appears to be no more than one influential outlier.

4.3.3 Mediation Analysis to Identify Indirect Predictors of Impact on Area-T1

Avoiding blame was the only Post-Event Characteristic that was found to be significant in the previous direct effect analysis. Table 32 presents mediation results. Significant p-values at adjusted alpha level are designated by an asterisk. In step one, the path a coefficient was significant at the $\alpha = 0.05/3 = 0.0167$ level for *experimentation and continuous improvement* and *work area routineness*. The path for *learning and stewardship* also had a small p-value (0.0237) and will be explored in the mediation analysis. In step two (Path b), the impact of *avoiding blame* on *Impact on Area-T1* while controlling for the potential predictor variable was significant for all of the input variables at the $\alpha = 0.05/3 = 0.0167$ level. Thus, mediation analysis results for *work area routineness, experimentation and continuous improvement*, and *learning and stewardship* is consistent with the mediation hypothesis that *work area routineness, experimentation and continuous improvement*, and *learning and stewardship* impacts *impact on area-T1* indirectly through *avoiding blame*. Path c' was significant for *work area routineness* at the adjusted alpha value which is consistent with a partial mediation effect that *work area routinenesss* significantly affects *impact on area-T1* both directly and indirectly through *avoiding blame*. This finding is consistent with the direct predictor findings presented in Section 4.4.1. Path c' was not significant for *experimentation and continuous improvement* at the adjusted alpha value which is consistent with a full mediation effect that *experimentation and continuous improvement* significantly affects *impact on area-T1*, but only indirectly through *avoiding blame*. Path c' was not significant for *learning and stewardship* at the adjusted alpha value but is significant at $\alpha = 0.05$. Furthermore, a partial mediation analysis would be consistent with the direct predictor findings that included *learning and stewardship* as a direct predictor of *impact on area-T1*. Thus, a partial mediation effect was explored.

For step 3, *avoiding blame* was regressed simultaneously on *work area routineness, experimentation and continuous improvement*, and *learning and stewardship*. As shown in Table 30, *work area routineness* and *experimentation and continuous improvement* were significant in this regression ($p < 0.05$), thus providing further support for their inclusion in the mediation hypothesis. However, *learning and stewardship* was not significant, which suggests that the variable should not be included as a mediating variable in the final model. Finally, *impact on area-T1* was regressed separately on *work area routineness* and *experimentation and continuous improvement*. In considering the direct effects of the input variables on the outcome, only

experimentation and continuous improvement had a significant direct effect at the 0.05 level. However, the p-value for *work area routineness* was p= 0.3617. Similar to the mediation analysis performed to examine *work area attitude and commitment* and *work area routineness* (see Section 4.2.2), suppressor effects appear to be evident in the model (MacKinnon et al., 2000). In this case, the direct effect is positive and the indirect effect is negative. The fact that *work area routineness* was included in two mediation models with different mediating variables may at least provide evidence that the influence of work area routineness should be further explored.In summary, *work area routineness* and *learning and stewardship* are both presented as fully mediated variables in the model of *impact on area-T1*.

Table 32. Mediation Analysis Results for Impact on Area-T1

Step 1: y'= Avoiding blame, separate regression	Coef. (a)	S.E.	p-value			
Goal Clarity	0.532	0.322	0.0983			
Goal Difficulty	0.159	0.228	0.4864			
Team Functional Heterogeneity	0.080	0.887	0.9282			
Management Support	0.441	0.292	0.1312			
Work Area Routineness	-0.426	0.133	0.0013*			
Management Change	-0.470	0.260	0.0712			
Production System Changes	0.178	0.204	0.3243			
Management Kaizen Event Participation at T1	-0.028	0.395	0.9443			
Management Kaizen Event Participation at T0	-0.190	1.098	0.8628			
Employee Change	-0.529	0.793	0.5046			
Learning and Stewardship	0.454	0.201	0.0237*			
Experimentation and Continuous Improvement	0.704	0.195	0.0003*			
Step 2: y'= Impact on area-T1, separate regression	**Coef. (b)**	**SE**	**p-value**	**Coef. (c')**	**SE**	**p-value**
Avoiding Blame				0.438	0.059	<.0001*
Work Area Routineness	0.310	0.127	0.0146*			
Avoiding Blame				0.344	0.086	<.0001*
Experimentation and Continuous Improvement	0.190	0.169	0.2599			
Avoiding Blame				0.312	0.076	<.0001*
Learning and Stewardship	0.349	0.167	0.0362			
Step 3: y'= Avoiding blame, simultaneous regression	**Coef. (a')**	**SE**	**p-value**			
Work Area Routineness	-0.316	0.147	0.0317			
Experimentation and Continuous Improvement	0.578	0.275	0.0354			
Learning and Stewardship	0.022	0.267	0.9337			
Step 4: y'= Impact on area-T1, separate regression	**Coef.**	**SE**	**p-value**			

Work Area Routineness	0.129	0.142	0.3617	
Experimentation and Continuous Improvement	0.391	0.167	0.0189	

Mediation Analysis Results for Avoiding blame and Impact on area-T1	Total mediated effect (a*b)	Partial or Full
Work Area Routineness	-0.186	Partial
Experimentation and Continuous Improvement	0.242	Full

4.4 Result Sustainability Model

4.4.1 Identification of Direct Predictors of Result Sustainability-Continuous Variable

The backward selection procedure and the hierarchical selection procedure, both using GEE model-based standard error estimates, converged upon a one-variable model (Table 33), *improvement culture* (β= 0.101, p=0.008), which was the second best one-variable model found by the R^2 selection procedure, but explained a small percentage of the outcome's variance (R^2 = 0.081). The OLS backward and stepwise regression procedures converged upon a one variable model that included *learning and stewardship* and was the best one variable model found by the R^2 and MAXR selection procedures but it was only significant at the 0.10 level. *Learning and stewardship* was significant at the 0.05 level using the GEE model-based standard error estimates (β= 0.111, p=0.009).

Table 33. Regression Model of Result Sustainability: Continuous Variable

	GEE β	SE GEE β	α MB	OLS β	SE OLS β	α OLS
Intercept	0.406	0.180	0.024	0.409	0.194	0.040
Improvement Culture	0.101	0.038	0.008	0.102	0.044	0.023
OLS R^2 = 0.082, OLS R_a^2 =0.067, F1,45= 5.42*						
GEE R^2 =0.086 GEE R_a^2 =0.071, ρ= -0.055						

Other potential variable combinations were explored. For example, a two-variable model including *learning and stewardship* (β= 0.0712, p=0.144) and *improvement culture* (β= 0.068, p=0.119) was explored but was not significant using the GEE model-based standard error estimates. Thus, it appears as though the modeling of *result sustainability* as a continuous variable is inconclusive.

The continuous measure of *goal achievement* from phase one of the OSU-VT research was also inconclusive. The variable *goal achievement* was explored which objectively measured

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the percentage of the primary goals achieved by the team at T0 (Farris, 2006). The explanatory power of the model of *goal achievement* as a continuous variable was low due to the skewness of the variable (35 of the 51 studied teams had *goal achievement* = 1.0). Similarly, *result sustainability* appeared to be negatively skewed and formal tests of normality were rejected (25 of 65 studied teams had *result sustainability* = 1.0). However, a log transformation did not improve the symmetry of their distribution and worsened the skewness values, so the untransformed variables were used in the analysis.

Therefore, similar to the study of *goal achievement* (Farris, 2006), in order to identify additional variables that may be critical factors of the relative *result sustainability*, *result sustainability* was transformed into a binomial variable, i.e., 1.0 if all results were sustained or exceeded, 0 otherwise, and a logistic regression was performed using SAS PROC GENMOD and the GEE model-based standard error estimates. The models were completed using a logit link function, a binomial distribution, and the descending option such that the results model the probability that *result sustainability* equals 1.0. Also, a logistic regression model using the Logistic Regression procedure in PASW 17.0 (an extension of SPSS) using weighted least squares (WLS) was explored to support the GEE findings. A backward selection procedure using the likelihood ratio statistic was used (Field, 2009).

4.4.2 Identification of Direct Predictors of Result Sustainability-Dichotomous Variable
The backward selection procedure and the hierarchical selection procedure, both using GEE model-based standard error estimates converged upon a four-variable model: *team functional heterogeneity* (β= -4.7356, p=0.0078), *performance review* (β= -0.6401, p=0.010), *learning and stewardship* (β= 2.0436, p=0.0112), and *experimentation and continuous improvement* (β= -1.3363, p=0.0383). The results of the weighted least squares (WLS) logistic regression using backward selection process based on the likelihood ratio statistic converged upon a five-variable model that included *improvement* culture in addition to the aforementioned variables. However, *improvement culture* was not significant using the GEE model-based standard error estimates. This, compared with the findings from the continuous measure of *result sustainability* that found *improvement culture* and *learning and stewardship* to be significant separately but not when combined in the same model may suggest that there is a relationship between *improvement culture* and *learning and stewardship* such that if one is in the model, the other does not explain

enough additional variance to justify its inclusion. Therefore, the four-variable model appears to be the best model for further analysis (Table 34).

Table 34. Logistic Regression Model for Result Sustainability-Dichotomous Variable

	GEE β	SE GEE	α GEE	OLSβ	SE OLS	α OLS
Intercept	0.705	1.877	0.707	-0.284	1.962	0.885
Team Functional Heterogeneity	-4.736	1.779	0.008	-3.840	1.814	0.034
Performance Review	-0.640	0.248	0.010	-0.437	0.271	0.107
Learning and Stewardship	2.044	0.806	0.011	1.847	0.762	0.015
Experimentation and Continuous Improvement	-1.336	0.645	0.038	-1.144	0.644	0.076
WLS R^2 = 0.229 (Negelkerke), WLS χ^2 (4)= 11.680* Hosmer-Lemeshow χ^2 (8) = 7.142, p= 0.512 GEE ρ = -0.056						

The regression coefficients and standard error estimates are similar for the GEE and OLS models. Also, the observed intraclass correlation reported by the GEE procedure was -0.0555. Because the observed intraclass correlation was negative, more variation occurs within between clusters (organizations) than within clusters (organizations). However, it should also be noted that the intraclass correlation may not be significantly different from zero. The Hosmer-Lemeshow statistic was also used, and is often used in logistic regression, to assess model fit. In order to calculate the Hosmer-Lemeshow statistic, the predicted event probabilities of the dependent variable observations are partitioned into ten equal sized groups according the percentiles of the predicted event probability. Then, a contingency table is constructed by cross-classifying the dichotomous dependent variable with the ten groups. Then, chi-square test is applied on the 2×10 contingency table (Hosmer and Lemeshow, 2000). A poor fit is indicated if the significance value of the chi-square test is less than 0.05 (Hosmer and Lemeshow, 2000; Field, 2009). The significance value for this model was 0.521 which indicates that the Hosmer-Lemeshow statistic shows no evidence of lack of fit.

The residual analysis revealed no significant evidence of departures from randomness in the residuals. Only one residual (3.029) was more than two standard deviations from zero, indicating that there at least appears to be no more than one influential outlier. Also, because

result sustainability was modeled as a dichotomous variable, its classification table was observed. The classification table shows the predicted versus observed classifications of the dataset. For each case, the predicted response is 'yes' if its model-predicted probability is greater than the specified cutoff value, with the default cutoff value of 0.5 (PASW, 2009). Nine of the events that met greater than or equal to 100% of their goals, i.e., *result sustainability* = 1, were misclassified as 0. These cases had predicted probabilities that ranged from 0.098 to 0.48707 which suggests that even if the cutoff value was slightly adjusted, the issue of misclassification would still be present. Ten of the events that met less than 100% of their goals, i.e., *result sustainability* = 0, were misclassified as 1. Four of these ten cases had continuous *result sustainability* values that were greater than 90%. This suggests that these four cases may be more similar to the more successful Kaizen events indicated by *result sustainability* = 1 as opposed to the less successful Kaizen events indicated by *result sustainability* = 0, and therefore have been misclassified as a 1. Six of these ten cases had continuous result sustainability values that ranged from 48% to 75%. Thus, overall, although it does not achieve perfect prediction, it seems that the model is somewhat successful at predicting group membership as 69.4% of cases were correctly classified.

4.4.3 Mediation Analysis to Identify Indirect Predictors of Result Sustainability-Dichotomous Variable

One post-event factor was a significant predictor for *result sustainability* − *performance review*. Again, *performance review* was separately regressed on all nine event input factors to determine which event input factors have a significant relationship to *performance review*. Path a was significant for *work area routineness* and *learning and stewardship* at the α = 0.05/3 = 0.0167 level. In step two, *performance review* was regressed on both the input variable (X) and *performance review*. As shown in Table 35, there was no indication that *performance review* mediated the effects of these variables – i.e., there was no support for the mediation hypothesis for *work area routineness* or *learning and stewardship*.

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Table 35. Mediation Analysis Results for Result Sustainability

Step 1: y'= Performance Review, separate regression	Coef. (a)	S.E.	p-value			
Goal Clarity	0.1902	0.3109	0.5407			
Goal Difficulty	0.1932	0.2204	0.3809			
Team Functional Heterogeneity	0.1835	0.8659	0.8322			
Management Support	0.1079	0.2896	0.7094			
Work Area Routineness	0.3529	0.1384	0.0108*			
Management Change	0.0519	0.2617	0.8429			
Production System Changes	0.0491	0.1987	0.805			
Management Kaizen Event Participation at T1	-0.2834	0.3877	0.4249			
Management Kaizen Event Participation at T0	-0.4146	1.069	0.6981			
Employee Change Ratio	-0.6978	0.837	0.4045			
Learning and Stewardship	0.6363	0.187	0.0007*			
Experimentation and Continuous Improvement	0.3239	0.194	0.095			

Step 2: y'= Work Area Attitude and Commitment, separate regression	Coef. (b)	SE	p-value	Coef. (c')	SE	p-value
Performance Review	0.1097	0.2925	0.7076			
Work Area Routineness				-0.1477	0.2193	0.5008
Performance Review	-0.2898	0.2494	0.2452			
Learning and Stewardship				0.6651	0.4391	0.1298

Mediation Analysis Results for Performance Review and Result Sustainability
No support for mediation.

4.5 Goal Sustainability Model

4.5.1 Identification of Direct Predictors of Goal Sustainability-Continuous Variable

The backward selection procedure and the hierarchical selection procedure, which used GEE model-based standard error estimates, and the OLS backward and stepwise regression procedures converged upon a one-variable model (Table 36) that included *learning and stewardship* ($\beta=$ 0.2644, p=0.0002). This was the best one-variable model found by the R^2 and MAXR selection procedures. However the one-variable model only explained a small percentage of the outcome's variance (GEE $R^2 = 0.165$).

Table 36. Regression Model of Goal Sustainability: Continuous Variable

	GEEβ	SE$_{MB}$ GEEβ	α $_{MB}$	OLSβ	SE OLSβ	α OLS
Intercept	-1.443	0.357	<.0001	-1.468	0.472	0.003
Learning and stewardship	0.264	0.072	0.000	0.283	0.101	0.008
OLS R^2 = 0.172, OLS R_a^2 =0.159, $F_{1,45}$= 12.67*** GEE R^2 =0.165, GEE R_a^2 =0.151, ρ= -0.055						

Similar to the continuous measure of *result sustainability,* the modeling of *goal sustainability* appears to have low explanatory power as a continuous variable. *Goal sustainability* was negatively skewed, and formal tests of normality on this variable were rejected. A log transformation of the variable was used for analysis, but this transformation does not alleviate the truncated nature of the dataset because 28 of 65 studied teams had *goal sustainability* = 1.0 (untransformed).   Therefore, *goal sustainability* was transformed into a binomial variable, i.e., 1.0 if all results were sustained or exceeded, 0 otherwise, and a logistic regression was performed.

4.5.2 Identification of Direct Predictors of Goal Sustainability-Dichotomous Variable

The backward selection procedure using GEE model-based standard error estimates and the weighted least squares (WLS) logistic regression models using both the forward and backward selection procedures based on the likelihood ratio statistic had no significant variables (Table 37). The inconclusive nature of this model may be partially explained by the way in which the goal sustainability was reported by research participants. *Goal sustainability* compares the T1 performance with the original goal set at T0. Both the extent to which the study respondents are able to report accurate and precise goals and T0 performance may influence the measure of *goal sustainability* and could cause the measure to be highly variable. Furthermore, the precision and accuracy of the respondents' T1 performance appeared to be highly variable. These concerns will be further explored in Chapter 5.

Table 37. Regression Results for Goal Sustainability-Dichotomous Variable

	GEE β	SE GEE	α GEE	OLS β	SE OLS	α OLS
Intercept	Inconclusive			0.214	0.293	0.467
WLS R^2 = 0.00 (Negelkerke)						

4.6 Post-Hoc Analyses: Testing Additional Variables and Outcome Correlation Analysis

Post-hoc analyses were performed to consider additional variables in the model (Section 4.6.1-4.6.4) and to assess the relationship between outcome variables (Section 4.6.5). A separate post-hoc analyses section is included to present alternative models of result sustainability and goal sustainability (see Section 4.7).

The following post-hoc analyses were conducted to determine whether any of the variation not accounted for in the final regression models could be accounted for by the inclusion of one or more additional variables. These variables were measured during data collection (some at T0 and some at T1) but were not explicitly tested in the primary analysis because either they were not believed to be key variables influencing event sustainability outcomes or they appeared to be very similar to one or more of the originally hypothesized model variables. The output of these post-hoc analyses are used to determine whether any of the post-hoc variables are significant in the final regression models, to evaluate the robustness of the final regression models, and to evaluate whether any of the post-hoc variables appear promising for future research.

As presented in Section 2.7.1, some of the Kaizen event team and process characteristics that were included in phase one of the OSU-VT research that considered in the initial success of Kaizen events, specifically *team Kaizen experience, team leader experience, team autonomy, event planning process, action orientation, internal processes, tool quality,* and *tool appropriateness* are not emphasized as critical factors in the sustainability literature, there was a lack of theoretical support for their inclusion as critical factors of Kaizen event outcome sustainability, and therefore were not included in the primary analysis. However, the indirect relationship between these factors and the Sustainability Outcomes may exist; therefore, these variables were included in post-hoc analysis. The description of each T0 variable is presented in Table 38. Next, the description of each T1 variable and the rationale for exclusion from the primary analysis is presented in Table 39. The descriptive statistics of all post-hoc variables are presented in Table 39. It should be noted that while the majority of the variables were relatively normally distributed, *tool appropriateness* was highly skewed due to a single outlier. However, a log transformation of the variable worsened the distributional properties of the data. Therefore, the original variable is retained for analysis and it should be noted that the outlier many end up being an influential case in the analyses.

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Table 38. T0 Variables Considered for Post-Hoc Analyses

Variable(s)	Description
Team Kaizen Experience	Data Collected through Report-Out Survey (at T0) *Previous Kaizen Event Experience* -- the number of previous Kaizen events in which each team member has participated. *Team Kaizen Experience* is computed as the average number of previous Kaizen events per team member.
Team Leader Experience	Data Collected through Event Information Sheet (at T0) *Team Leader Experience* –the total number of Kaizen events that the team leader has led or co-led.
Team Autonomy	Data Collected through Kickoff Survey (at T0) *Team Autonomy* –the amount of control over event activities that is given to Kaizen team members. 6-point Likert response scale; Example item TA1: "Our team had a lot of freedom in determining what changes to make to this work area."
Event Planning Process	Data Collected through Event Information Sheet (at T0) *Event Planning Process* –the total person-hours invested in planning the event
Action Orientation	Data Collected through Report-Out Survey (at T0) *Action Orientation* –the activities of the event team in terms of the extent to which team activities were focused on hands-on improvement activities – e.g., in the target work area or process – versus brainstorming and discussing solutions in offline team meetings – e.g., in meeting rooms. 6-point Likert response scale; Example item AO1: "Our team spent as much time as possible in the work area."
Affective Commitment To Change	Data Collected through Kickoff Survey (at T0) *Affective Commitment to Change* –team member perceptions of the need for the specific changes targeted by the Kaizen event. 6-point Likert response scale; Example item ACC2: "Most of our team members think that this Kaizen event is a good strategy for this work area."
Tool Quality	Data Collected through Event Information Sheet (at T0) *Tool Quality* -- For each problem-solving tool used by the team, the facilitator was asked to rate the *quality* of the team's use of the tool using a 6-point Likert response scale. *Tool quality* is calculated as the average *quality* rating across all tools.
Tool Appropriateness	Data Collected through Event Information Sheet (at T0) *Tool Appropriateness* -- For each problem-solving tool used by the team, the facilitator was asked to rate the *appropriateness* of using the tool to address the team's goals using a 6-point Likert response scale. *Tool appropriateness* is calculated as the average *appropriateness* rating across all tools.
Internal Processes	Data Collected through Report-Out Survey (at T0) *Internal Processes* –team member ratings of the internal harmony and coordination of their team. 6-point Likert response scale; Example item IP1: "Our team communicated openly."

Table 39. T1 Variables Considered for Post-Hoc Analyses

Variable(s)	Description	Rationale for Post-Hoc Consideration Only
Further Improvement Activities	Data Collected through PEIS (at T1) *Further Improvement Activities*: <u>Not</u> including closing out follow-up action items from the [insert name of Kaizen event], have any further improvement activities been conducted <u>as a result of</u> the Kaizen event? (1 = Yes, 2 = No) *Further Improvement Activities Extent:* If you selected YES, please rate the extent to which these <u>additional activities </u>have resulted in further improvement in the work area (6-point Likert response scale). Data Collected through PEIS (at T1) *Subsequent Kaizen Events:* Please list the <u>name</u>, the <u>start date (MM/DD/YY)</u> and the <u>primary objective(s)</u> of any other Kaizen events that have occurred in the work area **AFTER** the Kaizen event on [insert event dates].	Research participants may have responded to the question while referring to very different activities (i.e., not an "apples to apples" comparison). Also some of the Post Event Characteristics could be interpreted as further improvement activities (e.g., IChange3: Training work area employees in new work methods and processes from the Kaizen event). If *Further Improvement Activities* is significant, then *Further Improvement Activities extent* and *Subsequent Kaizen Events* will be further explored.
Immediate Follow-Up Actions	Data Collected through PEIS (at T1) *Immediate follow-up actions:* Whether there were immediate f/u action items that needed to be completed (1=yes, 2=no) *Immediate follow-up actions extent*: (1=all completed; 2= being completed; 3=not working towards completion)	Some of the Post Event Characteristics could be interpreted as immediate follow-up actions (e.g., IChange4: Updating work method and process documentation (e.g., standard work charts, formal job descriptions, etc.) for changes made due to the Kaizen event). If *Immediate follow-up actions* is significant, then *Immediate follow-up actions extent* will be further explored.
Changes Realistic	Data Collected through PEIS (at T1) *Changes Realistic:* Now, I believe the changes identified in the Kaizen event were realistic for day-to-day operations. (6-point Likert response scale)	Because *changes realistic* is a single-item measure, it was determined that the measure may be best considered for post-hoc analysis as opposed to being included in the Kaizen event outcome sustainability model.
Results Accurate	Data Collected through PEIS (at T1) *Results Accurate:* Now, I believe the estimated results at the end of the Kaizen event were accurate. (6-point Likert response scale)	Because *results accurate* is a single-item measure, it was determined that the measure may be best considered for post-hoc analysis as opposed to being included in the Kaizen event outcome sustainability model.
Accepting Changes-Retrospective	Data Collected through PEIS (at T1) This variable describes the extent to which work area management and employees accept changes made as	These items were very similar to the Post-Event Characteristic items

Measure	a result of the Kaizen event, employees follow the new work methods as a result of the Kaizen event, and employees are held accountable for following the new work methods as a result of the Kaizen event. Calculated as the average of survey items capturing respondent's perception of T1 ÷ average of survey items capturing respondent's perception of T0	(e.g., IChange3: Training work area employees in new work methods and processes from the Kaizen event or ICulture6: Work area management supporting the use of Kaizen events in the work area).
	6-point Likert response scale	Note: In addition to the ratio calculation of calculation of *Accepting Changes-Retrospective Measure*, a calculation of Accepting Changes that only included respondent's perceptions of T1 was also considered.
	Respondent Accepting Changes Perception of T1 RETRO2-1: Now, the *management* of the work area accepts the changes made as a result of the Kaizen event. RETRO3-1: Now, the *management* of the work area holds employees accountable for following the new work methods from the Kaizen event. RETRO4-1: Now, employees in the work area accept the changes made as a result of the Kaizen event. RETRO5-1: Now, employees in the work area follow the new work methods from the Kaizen event.	
	Respondent Accepting Changes Perception of T0 RETRO2-0: Initially, the *management* of the work area accepted the changes made as a result of the Kaizen event. RETRO3-0: Initially, the *management* of the work area held employees accountable for following the new work methods from the Kaizen event. RETRO4-0: Initially, employees in the work area accepted the changes made as a result of the Kaizen event. RETRO5-0: Initially, employees in the work area followed the new work methods from the Kaizen event.	
Overall Success	Single-item measure using a 6-point Likert response scale (Farris, 2006): OVER: "Now, I believe that overall, the kaizen event was a success"	Because *overall success* is a single-item measure and exploration of the *overall success* as an immediate outcome of a Kaizen event was inconclusive in the first phase of the OSU-VT research (Farris, 2006), it was determined that the measure would be best considered for post-hoc analysis as opposed to being included in the Kaizen event outcome sustainability model.

Table 40. Descriptive Statistics of Post-Hoc Variables

	Continuous Variables					
	Minimum	**Maximum**	**Mean**	**Std. Deviation**	**Skewness**	**Skewness Std. Error**
Team Autonomy	3.42	5.56	4.79	0.45	-0.75	0.30
Team Kaizen Experience[a]	0.00	1.54	0.65	0.41	0.39	0.30
Team Leader Experience[a]	0.00	1.53	0.49	0.44	0.48	0.30
Event Planning Process[a]	0.30	2.08	1.04	0.49	0.41	0.30
Affective Commitment to Change	3.79	5.73	4.79	0.44	-0.04	0.30
Action Orientation	2.36	5.67	4.23	0.70	-0.37	0.30
Internal Processes	4.28	5.80	5.16	0.37	-0.47	0.30
Tool Appropriateness	1.00	6.00	5.43	0.72	-3.87	0.30
Tool Quality	1.00	6.00	4.72	0.90	-1.22	0.30
Changes Realistic	1.00	6.00	4.98	0.91	-1.51	0.30
Results Accurate	1.00	6.00	4.80	0.97	-1.27	0.30
Accepting Changes-Retrospective Measure	0.67	1.41	1.03	0.15	0.10	0.30
Accepting Changes	1.00	6.00	4.79	1.09	-1.35	0.30
Overall Success						
	Binary Variables					
Further Improvement Activities	Yes=28 No=35					
Immediate Follow-up Actions	Yes=48 No=12					

[a] Due to strong departures from normality, the original variable was log transformed for modeling purposes; the statistics reported here are based on the transformed values

4.6.1 Post-Hoc Analysis of Work Area Attitude and Commitment

The manual backward selection procedure and the hierarchical selection procedure, both using GEE model-based standard error estimates still converged upon a two predictor model found during the primary analysis, *performance review* (β= 0.193, p=0.003) and *experimentation and continuous improvement* (β= 0.389, p=0.002). Using the backward and stepwise OLS regression procedures, *performance review, experimentation and continuous improvement,* and *accepting changes-retrospective measure* were found to be significant at the 0.05 level. This solution was not significant using the GEE model-based standard error estimates at adjusted α level (.1/4=0.025), but was significant at the 0.05 level (Table 41).

Table 41. Regression Model of Work Area Attitude and Commitment For Post-Hoc Analysis

	GEE β	SE GEE β	α GEE	OLS β	SE OLS β	α OLS
Intercept	1.029	0.665	0.122	0.682	0.672	0.314
Performance Review	0.159	0.066	0.016	0.179	0.067	0.010
Experimentation and Continuous Improvement	0.402	0.104	0.000	0.450	0.107	<.0001
Accepting Changes-Retrospective Measure	1.048	0.481	0.029	1.160	0.536	0.035
OLS R^2 = 0.460, OLS R_a^2 = 0.432, F3,58 = 16.46*** GEE R^2 =0.462, GEE R_a^2 =0.434, ρ= 0.245						

An alternative of *accepting changes-retrospective measure* was also considered. *Accepting changes* describes the extent changes made during Kaizen event are accepted, followed, and reinforced 'now' (i.e., no comparison to 'initial' perceptions). The manual backward selection procedure and the hierarchical selection procedure, both using GEE model-based standard error estimates, as well as the backward and stepwise OLS regression procedures converged upon a three predictor model, *performance review, experimentation and continuous improvement,* and *accepting change* (Table 42).These variables were found to be significant at the adjusted α level (.1/4=0.025). Because the model that included *accepting changes* was significant at the adjusted α level and explained more variance than the model that included *accepting changes-retrospective measure,* the three predictor model including *performance review, experimentation and continuous improvement,* and *accepting change* was adopted. Inclusion of this variable increased the OLS R^2 value from the original model (see Section 4.2.1) from R^2=0.419 to R^2= 0.504. The inclusion of *accepting changes* as a significant and positive predictor of *work area attitude and commitment* suggests that as the work area's acceptance, accountability, and follow-through of changes as a result of the Kaizen event increase, the attitude and commitment to Kaizen events also increases. These findings suggest that further study of *accepting changes* may assist in explaining Kaizen event outcome sustainability, particularly when *work area attitude and commitment* is the outcome variable of interest.

Table 42. Regression Model of Attitude and Commitment After Post-Hoc Analysis

	GEE β	SE GEE	α GEE	OLS β	SE OLS	α OLS
Intercept	1.653	0.467	0.000	1.380	0.437	0.003
Performance Review	0.161	0.064	0.012	0.168	0.063	0.010
Experimentation and Continuous Improvement	0.288	0.107	0.007	0.301	0.111	0.009
Accepting Changes	0.202	0.072	0.005	0.247	0.076	0.002
OLS R^2= 0.504, OLS R_a^2 = 0.479, F3, 59=20.001***						
GEE R^2=0.503, GEE R_a^2 =0.477, ρ= 0.175						

Similar to the original findings, the regression coefficients are similar for the GEE estimation versus the OLS estimation. The observed intraclass correlation reported by the GEE procedure was 0.1750, which is slightly less than the correlation from the original model prior to the post-hoc analysis (0.2635), but still suggests that there is more variation that occurs within clusters versus between clusters (organizations).

For the residual analysis, the residual plots and partial regression plots did not indicate departures from linearity. Observation of the residual outliers revealed that the largest absolute value was 1.697, indicating that there was no strong evidence of influential cases. However, the Wald-Wolfowitz run test (Chang, 2000) did not indicate that there was a random pattern in the residuals ($p = 0.003$). Graphical observation of the residuals by organization suggested that the lack of randomness in the residuals may be caused by heteroscedasticity at the organizational level; i.e., organizational level effects may influence the variation of the residuals such that the variance is not similar in each organization.   Transformations of the data did not resolve this issue. Therefore, it is possible that the inclusion of additional organizational or event level variables that were not tested in the research may improve the overall model fit. To explore this possibility, the additional variables, *previous Kaizen events, subsequent Kaizen events,* and the *number of work area employees at T1*, were tested but were not significant. While the heteroscedasticity potentially presents limitations regarding the generalizability of the findings, conclusions regarding the sample can still be made and the variables identified in the model may still be among the most influential in explaining *work area attitude and commitment*. These findings suggest that future research, including the testing of additional organizational and event level variables and the consideration of other multilevel modeling approaches, e.g., HLM, is needed to further explore the specification of this model.

Because the post-hoc variable, *accepting changes*, was found to be a significant predictor, the most appropriate place or role of the variable within the larger research model was considered, i.e., whether *accepting changes* should be classified as a Kaizen Event Characteristic, Work Area Characteristic, or Post-Event Characteristic. *Accepting changes* describes the extent to which work area management and employees accept changes made as a result of the Kaizen event, employees follow the new work methods as a result of the Kaizen event, and employees are held accountable for following the new work methods as a result of the Kaizen event.

Accepting changes is most similar to the Post-Event Characteristics that are included in the research model. *Accepting changes* refers to the socialization of the change (socialization) and the commitment of the individual to the change (commitment) which were institutionalization processes in the models of institutionalizing change (Goodman and Dean, 1982; Cummings and Worley, 1997). Because *accepting changes* may be considered as an additional Post-Event Characteristic to the research model, the validity of *accepting changes* as a stand-alone variable was assessed by conducting a factor analysis with the other Post-Event Characteristic survey scales (Table 43). Also, the bivariate correlations between *accepting changes* and the other Post-Event Characteristics were observed (Table 44). In summary, the *accepting changes* items load separately when included with the items of the post-event characteristics. PR2 does have a slightly higher cross-loading with the *accepting changes* items (0.326). The Post-Event Characteristics were significantly correlated but not highly correlated such that issues of multicollinearity would be present.

Table 43. Pattern Matrix for Accepting Changes and Post-Event Characteristic Survey Scales

	Component				
	1	2	3	4	5
IChange1	**0.883**				
PR3	**0.754**				
IChange5	**0.747**				
IChange2	**0.717**				
IChange4	**0.653**				
IChange3	**0.641**				

	1	2	3	4	5
RETRO2-1		**0.897**			
RETRO4-1		**0.861**			
RETRO5-1		**0.858**			
RETRO3-1		**0.788**			
PR7			**-0.835**	0.255	
PR4			**-0.799**		
PR1		0.276	**-0.787**		
PR2		0.326	**-0.722**		
PR5			**-0.719**		
ICulture3				**0.948**	
ICulture4				**0.928**	
ICulture7					**0.888**
ICulture6					**0.861**
ICulture8	0.251				**0.693**

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
a. Rotation converged in 8 iterations.

Table 44. Bivariate Correlations of Accepting Changes and Post-Event Characteristics

	Institutionalizing Change	Improvement Culture	Performance Review	Avoiding Blame
Pearson Correlation	.356[**]	.413[**]	.376[**]	.406[**]
Sig. (2-tailed)	.004	.001	.002	.001
Kendall's tau_b Correlation Coefficient	.211[*]	.340[**]	.298[**]	.359[**]
Sig. (2-tailed)	.023	.000	.001	.000
Spearman's rho Correlation Coefficient	.288[*]	.415[**]	.389[**]	.460[**]
Sig. (2-tailed)	.022	.001	.002	.000

Table 45 presents the results of the mediation analysis of *accepting changes* and *work area attitude and commitment*. In the first step of the mediation analysis, *accepting changes* is separately regressed on all nine event input factors to determine which event input factors have a significant relationship to *accepting changes*. Path a was significant at the $\alpha = 0.05/3 = 0.0167$ level for *learning and stewardship* and *experimentation and continuous improvement*. The path

for *production system changes* also had a small p-value (0.0186) and was explored in step two of the mediation analysis.

For step 2, Path b was significant for *production system changes* and *experimentation and continuous* at the α = 0.05/3 = 0.0167 level. Thus, mediation analysis results for *production system changes,* and *experimentation and continuous improvement* is consistent with the mediation hypothesis that *production system changes* and *experimentation and continuous improvement* impacts *work area attitude and commitment* indirectly through *accepting changes*. Path b was not significant at the α = 0.05/3 = 0.0167 level for *learning and stewardship*.

Path c' was significant for *experimentation and continuous improvement* at the adjusted alpha value which is consistent with a partial mediation effect that *experimentation and continuous improvement* significantly affects *work area attitude and commitment* both directly and indirectly through *accepting changes*. This is consistent with the direct effect regression finding that *experimentation and continuous improvement* significantly affects *work area attitude and commitment*. Path c' was not significant for *production system changes* at the adjusted alpha value which is consistent with a full mediation effect that *production system changes* significantly affects *work area attitude and commitment*, but only indirectly through *accepting changes*.

For step 3, *accepting changes* was regressed simultaneously on *production system changes* and *experimentation and continuous improvement*. *Production system changes* and *experimentation and continuous improvement* were significant in this regression ($p < 0.05$), thus providing further support for their inclusion in the mediation hypothesis. Finally, *work area attitude and commitment* was regressed separately on *production system changes* and *experimentation and continuous improvement*. In considering the direct effects of the input variables on the outcome, *experimentation and continuous improvement* ($\beta=0.449$, $p<0.0001$) was significant. *Production system changes* ($\beta= 0.095$, $p=0.3461$) was not significant. In this case the direct effect and indirect effect of production system changes was positive. Conceptually, the finding may relate to both suppressor and confounding effects (MacKinnon et al., 2000), i.e., the increase in the magnitude of the effect of *production system changes* on *work area attitude and commitment* may have occurred because *accepting changes* explained variability in *production system changes*. The relationship is retained in the final model and is explored in the interpretation of the results (see Section 5.1.1).

In summary, *production system changes* and *experimentation and continuous improvement* are presented as fully mediated variables in the model of *work area attitude and commitment*.

Table 45. Post-Hoc Mediation Analysis Results for Attitude and Commitment

Step 1: y'=Accepting Changes, separate regression	Coef. (a)	S.E.	p-value			
Goal Clarity	-0.194	0.270	0.4733			
Goal Difficulty	-0.160	0.205	0.4348			
Team Functional Heterogeneity	0.771	0.769	0.3158			
Management Support	0.250	0.257	0.3295			
Work Area Routineness	0.255	0.130	0.0509			
Management Change	-0.340	0.243	0.1624			
Production System Changes	0.408	0.173	0.0186 *			
Management Kaizen Event Participation at T1	0.195	0.345	0.5732			
Management Kaizen Event Participation at T0	0.820	0.957	0.3914			
Employee Change	0.631	0.567	0.2651			
Learning and Stewardship	0.884	0.155	<.0001*			
Experimentation and Continuous Improvement	0.553	0.171	0.0012*			

Step 2: y'= Work Area Attitude and Commitment, separate regression	Coef. (b)	SE	p-value	Coef. (c')	SE	p-value
Accepting Changes	0.299	0.071	<0.0001*			
Production System Changes				-0.028	0.110	0.8017
Accepting Changes	0.226	0.071	0.0014*			
Experimentation and Continuous Improvement				0.332	0.106	0.0018*
Accepting Changes	0.165	0.079	0.0375			
Learning and Stewardship				0.354	0.121	0.0035*

Step 3: y'= Accepting Changes, simultaneous regression	Coef. (a')	SE	p-value	
Production System Changes	0.362	0.176	0.0403*	
Experimentation and Continuous Improvement	0.514	0.169	0.0023*	

Step 4: y'= Work Area Attitude and Commitment, separate regression	Coef.	SE	p-value
Production System Changes	0.095	0.101	0.3461
Experimentation and Continuous Improvement	0.449	0.100	<0.0001*

Mediation Analysis Results for Accepting Changes and Work Area Attitude and Commitment	Total mediated effect (a*b)	Partial or Full
Production System Changes	0.122	Partial
Experimentation and Continuous Improvement	0.125	Full

4.6.2 Post-Hoc Analysis of Impact on Area-T1

Post-hoc analysis of the *impact on area-T1* model found that one variable, *accepting changes,* was significant and positively related to *impact on area-T1* (Table 46). The significance of *accepting changes* suggests that as the work area's acceptance, accountability, and follow-through of changes as a result of the Kaizen event increase, the perception of the Kaizen event's impact on the work area also increases. Inclusion of *accepting changes* increased the OLS R^2 value from the original model from R^2=0.270 to R^2= 0.536. However, when *accepting changes* is added to the model, the direct effects of *avoiding blame* (β= 0.122, p=0.097) and *work area routineness* (β= 0.038, p= 0.739) are no longer significant. In fact, *accepting changes* appears to explain approximately 50% of the variation of the outcome. The fact that the post-hoc analysis led to the exclusion of several variables that were previously found to be significant to *impact on area-T1* may suggest that the regression model is less robust when compared to the initial *impact on area-T1* (see Section 4.3.2) and requires further study. In summary, these findings suggest that further study of *accepting changes* may assist in explaining Kaizen event outcome sustainability, particularly when *impact on area-T1* is the outcome variable of interest.

Table 46. Regression Model for Impact on Area-T1 After Post-Hoc Analysis

	GEE β	SE GEE	α GEE	OLS β	SE OLS	α OLS
Intercept	1.373	0.378	0.000	1.275	0.421	0.004
Accepting changes	0.658	0.073	<.0001	0.683	0.086	<.0001
OLS R^2= 0.506, OLS R_a^2 = 0.498, F1, 62=63.61***						
GEE R^2= 0.512, GEE R_a^2 = 0.504, ρ= -0.043						

For the resultant model of *impact on area-T1* (Table 46), the observed intraclass correlation reported by the GEE procedure was -0.043 which suggests that more variation occurs between clusters (organizations) than within clusters. The residual plots and partial regression plots did not indicate departures from linearity. Observation of the residual outliers revealed that the largest absolute value was 1.987, indicating that there was no strong evidence of influential cases. Also, the Wald-Wolfowitz run test indicated that the residuals appeared to exhibit a random pattern (p=0.276).

Again, because *accepting changes* may be considered as an additional Post-Event Characteristic, the potential role of *accepting changes* as a mediating variable in the model was explored. Table 47 presents the results of the mediation analysis. In the first step of the mediation analysis, *accepting changes* was found to have a significant relationship with *learning and stewardship* and *experimentation and continuous improvement*. The path for *production system changes* also had a small p-value (0.0186) and will be explored in step two.

For step 2 (Path b), the impact of *accepting changes* on *impact on area-T1* while controlling for the predictor (X) was significant for *production system changes, learning and stewardship,* and *experimentation and continuous* at the $\alpha = 0.05/3 = 0.0167$ level. Thus, mediation analysis results for *production system changes, learning and stewardship,* and *experimentation and continuous improvement* is consistent with the mediation hypothesis that *production system changes, learning and stewardship,* and *experimentation and continuous improvement* impacts *impact on area-T1* indirectly through *accepting changes*.

Path c' was not significant for *production system changes, learning and stewardship,* or *experimentation and continuous improvement* at the adjusted alpha value which is consistent with a full mediation effect that *production system changes, learning and stewardship,* and *experimentation and continuous improvement* impacts significantly affect *impact on area-T1*, but only indirectly through *accepting changes*.

For step 3, *accepting changes* was regressed simultaneously on *production system changes, learning and stewardship,* and *experimentation and continuous improvement*. *Learning and stewardship* was significant in this regression ($p < 0.05$), thus providing further support for their inclusion in the mediation hypothesis. However, *production system changes* and *experimentation and continuous improvement* were not significant, suggesting that *production system changes* and *experimentation and continuous improvement* should not be included as mediating variables in the final model. Finally, *impact on area-T1* was regressed on *learning and stewardship*. In considering the direct effects of the input variables on the outcome, *learning and stewardship* had a significant direct effect at the 0.05 level, further supporting its inclusion in the model ($\beta= 0.5294$, $p=0.009$). In summary, *learning and stewardship* are presented as fully mediated variables in the model of *impact on area-T1*.

Table 47. Post-Hoc Mediation Analysis Results for Impact on Area-T1

Step 1: y'=Accepting Changes, separate regression	Coef. (a)	S.E.	p-value			
Goal Clarity	-0.194	0.270	0.4733			
Goal Difficulty	-0.160	0.205	0.4348			
Team Functional Heterogeneity	0.771	0.769	0.3158			
Management Support	0.250	0.257	0.3295			
Work Area Routineness	0.255	0.130	0.0509			
Management Change	-0.340	0.243	0.1624			
Production System Changes	0.408	0.173	0.0186*			
Management Kaizen Event Participation at T1	0.195	0.345	0.5732			
Management Kaizen Event Participation at T0	0.820	0.957	0.3914			
Employee Change	0.631	0.567	0.2651			
Learning and Stewardship	0.884	0.155	<.0001*			
Experimentation and Continuous Improvement	0.553	0.171	0.0012*			
Step 2: y'= Impact on area-T1, separate regression	**Coef. (b)**	**SE**	**p-value**	**Coef. (c')**	**SE**	**p-value**
Accepting Changes	0.658	0.079	<0.0001*			
Production System Changes				0.004	0.148	0.9796
Accepting Changes	0.712	0.091	<0.0001*			
Experimentation and Continuous Improvement				-0.138	0.138	0.3182
Accepting Changes	0.745	0.103	<0.0001*			
Learning and Stewardship				-0.207	0.172	0.2269
Step 3: y'= Accepting Changes, simultaneous regression	**Coef. (a')**	**SE**	**p-value**			
Production System Changes	0.209	0.160	0.1913			
Learning and Stewardship	0.794	0.224	0.0004*			
Experimentation and Continuous Improvement	0.080	0.219	0.7144			
Step 4: y'= Impact on Area-T1, separate regression	**Coef.**	**SE**	**p-value**			
Learning and Stewardship	0.529	0.171	0.009*			
Mediation Analysis Results for Accepting Changes and Impact on Area-T1	**Total mediated effect (a*b)**		**Partial or Full**			
Learning and Stewardship	0.6589		Full			

4.6.3 Post-Hoc Analysis of Result Sustainability

Post-hoc analysis of the dichotomous *result sustainability* model found that one additional variable, *event planning process* was significant and negatively related to *result sustainability* (Table 48), which suggests that as the number of hours spent planning the Kaizen event increases, the percentage of the results that have been sustained from T0 to T1 decreases.

Similar to some of the other negative relationships included in the model (e.g., *performance review*), the negative relationship between *event planning process* and *result sustainability* may perhaps be explained by the way *result sustainability* is measured. For example, an organization that extensively plans before the Kaizen event may have a more accurate (objective) measure of its *result sustainability*. Conversely, an organization that invests fewer hours in planning before a Kaizen event may not have detailed information about their *result sustainability* (e.g., they may be more likely to report *result sustainability* subjectively such as "yes, the results were sustained" as opposed to being able to report "we've sustained 90% of our results").

Inclusion of *event planning process* increased the Nagelkerke R^2 value from the original model from R^2=.229 to R^2= 0.274. However, when *event planning process* is added to the model, the direct effect of *team functional heterogeneity* (β= -3.188, p=0.101) is no longer significant. The fact that the post-hoc analysis led to the exclusion of several variables that were previously found to be significant to *result sustainability* may suggest that the regression model is less robust when compared to the initial *result sustainability* (see Section 4.4.2). Additional study is needed to further test the robustness of the model. In summary, there is support for the inclusion of *event planning process* in the modeling of *result sustainability*.

Table 48. Regression Model for Result Sustainability After Post-Hoc Analysis

	GEE β	SE GEE	α GEE	OLS β	SE OLS	α OLS
Intercept	1.522	1.915	0.427	0.322	2.013	0.873
Performance Review	-0.681	0.240	0.005	-0.401	0.267	0.133
Learning and Stewardship	2.239	0.829	0.007	2.087	0.809	0.010
Experimentation and Continuous Improvement	-1.816	0.705	0.010	-1.591	0.709	0.025
Event Planning Process	-1.803	0.631	0.004	-1.670	0.653	0.011
WLS R^2 = 0.274 (Negelkerke); WLS χ^2 (4)= 14.282** Hosmer-Lemeshow statistic χ^2 (8)= 8.30, p=0.405 GEE ρ = *-0.0555*						

The observed intraclass correlation reported by the GEE procedure was -0.0555. Because the observed intraclass correlation was negative, more variation occurs between clusters (organizations) than within clusters (organizations). However, it should also be noted that the intraclass correlation may not be significantly different from zero. The Hosmer-Lemeshow statistic was also used to assess model fit. The Hosmer-Lemeshow statistic is used in binary logistic regression and indicates a poor fit if the significance value is less than 0.05 (Field, 2009). The significance value for this model was 0.405 which indicates that the model appears to adequately fit the data (i.e., there is a lack of evidence of lack of fit).

The residual analysis revealed that there was no significant evidence of departures from randomness in the residuals. No outlier residuals were found to be more than two standard deviations from zero, indicating that there was no strong evidence of influential cases. Finally, the classification table was observed. Eleven of the events that met greater than or equal to 100% of their goals, i.e., result sustainability = 1, were misclassified as 0. These cases had predicted probabilities that ranged from 0.2128 to 0.4502 which suggests that even if the cutoff value was slightly adjusted, the issue of misclassification would still be present. Ten of the events that met less than 100% of their goals, i.e., result sustainability = 0, were misclassified as 1. Four of these ten cases had continuous result sustainability values that were greater than 80%, which suggests that they may share more common characteristics with more versus less successful characteristics and therefore have been misclassified as 1. The other six cases had continuous result sustainability values that ranged from 0% to 75%. Thus, overall it seems that the model is reasonably successful at predicting group membership as 66.1% of cases were still correctly classified.

4.6.4 Post-Hoc Analysis of Additional Outcome, Overall Success

The additional Kaizen event Sustainability Outcome, *overall success* (OVER: "Now, I believe that overall, the kaizen event was a success") was considered in post-hoc analysis. This Sustainability Outcome was not included in the original model of Kaizen event sustainability because *overall success* is a single-item measure and exploration of the *overall success* as an immediate outcome of a Kaizen event was inconclusive in the first phase of the OSU-VT research (Farris, 2006). The procedures presented in Section 4.1.1 were used to model *overall*

success. The significance of the originally hypothesized variables was tested first. Then, the post-hoc independent variables were added to the regression model and explored.

The backward selection procedure and the hierarchical selection procedure, both using GEE model-based standard error estimates, and the backward and stepwise OLS regression procedures converged upon a two predictor solution: *results accurate* (β= 0.535, p=0.000) and *accepting changes* (β= 0.651, p < 0.0001) . The GEE R^2 is approximately 45%, which indicates that the model does explain a moderate amount of the outcome's variation (Table 49).

Table 49. Regression Model for Overall Success

	GEE β	SE GEE	α GEE	OLS β	SE OLS	α OLS
Intercept	-0.631	0.625	0.312	0.210	0.629	0.740
Results Accurate	0.535	0.108	<.0001	0.462	0.120	0.000
Accepting Changes	0.651	0.099	<.0001	0.516	0.107	<.0001
OLS R^2 = 0.492, OLS R_a^2 = 0.475, F2,61 = 29.49***						
GEE R^2 = 0.451, GEE R_a^2 =0.433, ρ= 0.347						

Similar to the findings for *work area attitude and commitment*, the observed intraclass correlation reported by the GEE procedure was positive (0.347). Because the observed intraclass correlation was positive, more variation occurs within clusters versus between clusters (organizations), providing additional support for the use of the exchangeable matrix for the GEE analysis to study this outcome

Finally, the residual analysis was conducted. The residual plots and partial regression did present some patterns that may indicate slight departures from linearity (Field, 2009). Observation of the residual outliers revealed that the largest absolute value was 2.423, indicating that there at least appears to be no more than one influential outlier. However, the Wald-Wolfowitz run test not did indicate that there was a random pattern in the residuals (p = 0.030). As conducted for the work area attitude and commitment model, a random effects model was explored using PROC MIXED with the 'subject=' option (subject=org) (Chang, 2000). While the model variables were still significant and had similar magnitudes as found in the GEE and OLS models, the runs tests still indicated that the residuals did not exhibit a random pattern (p= 0.034). These findings suggest that additional research is needed to further explore the specification of this model.

Again, because *accepting changes* may be considered as an additional Post-Event Characteristic, the potential role of *accepting changes* as a mediating variable in the model was explored. Table 50 presents the results of the mediation analysis. In the first step of the mediation analysis, *accepting changes* was found to have a significant relationship with *learning and stewardship* and *experimentation and continuous improvement*. The path for *production system changes* also had a small p-value (0.0186) and was explored in step two.

For step 2 (Path b), the impact of *accepting changes* on *overall success* while controlling for the predictor (X) was significant for *production system changes, learning and stewardship,* and *experimentation and continuous* at the $\alpha = 0.05/3 = 0.0167$ level. Thus, mediation analysis results for *production system changes, learning and stewardship,* and *experimentation and continuous improvement* is consistent with the mediation hypothesis that *production system changes, learning and stewardship,* and *experimentation and continuous improvement* impacts *overall success* indirectly through *accepting changes*. Path c' was not significant for *production system changes, learning and stewardship,* or *experimentation and continuous improvement* at the adjusted alpha value which is consistent with a full mediation effect that *production system changes, learning and stewardship,* and *experimentation and continuous improvement* impacts significantly affect *overall success*, but only indirectly through *accepting changes*.

For step 3, *accepting changes* was regressed simultaneously on *production system changes, learning and stewardship,* and *experimentation and continuous improvement*. *Learning and stewardship* was significant in this regression (p < 0.05), thus providing further support for their inclusion in the mediation hypothesis. However, *production system changes* and *experimentation and continuous improvement* were not significant, suggesting that *production system changes* and *experimentation and continuous improvement* should not be included as mediating variables in the final model. Finally, *overall success* was regressed on *learning and stewardship*. In considering the direct effects of the input variables on the outcome, *learning and stewardship* had a significant direct effect at the 0.05 level, further supporting its inclusion in the model ($\beta = 0.6435$, p=0.0012). In summary, *learning and stewardship* are presented as fully mediated variables in the model of *work area attitude and commitment*.

Table 50. Mediation Analysis Results for Overall Success

Step 1: y'=Accepting Changes, separate regression	Coef. (a)	S.E.	p-value			
Goal Clarity	-0.194	0.270	0.4733			
Goal Difficulty	-0.160	0.205	0.4348			
Team Functional Heterogeneity	0.771	0.769	0.3158			
Management Support	0.250	0.257	0.3295			
Work Area Routineness	0.255	0.130	0.0509			
Management Change	-0.340	0.243	0.1624			
Production System Changes	0.408	0.173	0.0186*			
Management Kaizen Event Participation at T1	0.195	0.345	0.5732			
Management Kaizen Event Participation at T0	0.820	0.957	0.3914			
Employee Change	0.631	0.567	0.2651			
Learning and Stewardship	0.884	0.155	<.0001*			
Experimentation and Continuous Improvement	0.553	0.171	0.0012*			

Step 2: y'= Overall Success, separate regression	Coef. (b)	SE	p-value	Coef. (c')	SE	p-value
Accepting Changes	0.713	0.120	<.0001*			
Production System Changes				0.130	0.188	0.4902
Accepting Changes	0.759	0.125	<.0001*			
Experimentation and Continuous Improvement				-0.157	0.185	0.3954
Accepting Changes	0.715	0.143	<.0001*			
Learning and Stewardship				0.054	0.217	0.8049

Step 3: y'= Accepting Changes, simultaneous regression	Coef. (a')	SE	p-value
Production System Changes	0.200	0.164	0.224
Learning and Stewardship	0.895	0.225	<.0001*
Experimentation and Continuous Improvement	-0.089	0.214	0.6793

Step 4: y'= Accepting Changes, simultaneous regression	Coef.	SE	p-value
Learning and Stewardship	0.644	0.199	0.0012*

Mediation Analysis Results for Avoiding blame and Overall Success	Total mediated effect (a*b)	Partial or Full
Learning and Stewardship	0.6322	Full

4.6.5 Correlation Analysis of Outcomes

Finally, post-hoc analyses of the correlation between Sustainability Outcomes were conducted (Table 51). Both the Pearson correlation coefficient (OLS) and the GEE correlation coefficient were calculated. The GEE correlation coefficient was calculated as the as the square root of the coefficient of determination for the regression model where one of the two outcomes was regressed on the other. Because the GEE correlation coefficient was based on the regression

modeling, the continuous measure of both *result sustainability* and *goal sustainability* was used. To account for the difference in regressing X on Y versus Y on X, both regressions were modeled. The reported significance of the GEE correlation coefficient is the significance of the model regression coefficient. A Bonferroni correction is used to adjust the alpha value for the number of planned comparisons (10 pairwise comparisons), i.e., the alpha value of $0.05/10 = 0.005$ was used to assess the significance of each correlation. Table 59 includes the two GEE coefficient findings and the two p-values for each pairwise relationship as well as the Pearson correlation coefficient and significance.

Table 51. Pairwise Correlations for Outcome Variables and Regression Significance Tests

Response (Predictor)	Correlation Coefficient GEE	α GEE	Correlation Coefficient OLS	α OLS
Work Area Attitude and Commitment (Impact on Area-T1)	0.414	0.000	0.464	<.0001
Impact on Area-T1(Work Area Attitude and Commitment)	0.464	<.0001	0.464	<.0001
Work Area Attitude and Commitment (Goal Sustainability)	0.293	0.000	0.286	0.023
Goal Sustainability (Work Area Attitude and Commitment)	0.263	0.017	0.286	0.023
Work Area Attitude and Commitment (Result Sustainability)	0.218	0.003	0.205	0.107
Result Sustainability (Work Area Attitude and Commitment)	0.195	0.168	0.205	0.107
Impact on Area-T1(Goal Sustainability)	0.645	<.0001	0.646	<.0001
Goal Sustainability (Impact on Area-T1)	0.645	<.0001	0.646	<.0001
Impact on Area-T1(Result Sustainability)	0.578	<.0001	0.579	<.0001
Result Sustainability (Impact on Area-T1)	0.578	<.0001	0.579	<.0001
Goal Sustainability (Result Sustainability)	0.877	<.0001	0.877	<.0001
Result Sustainability (Goal Sustainability)	0.877	<.0001	0.877	<.0001
Overall Success (Impact on Area-T1)	0.565	<.0001	0.565	<.0001

Impact on Area-T1(Overall Success)	0.563	<.0001	0.565	<.0001
Overall Success (Goal Sustainability)	0.346	0.003	0.346	0.005
Goal Sustainability (Overall Success)	0.344	0.005	0.346	0.005
Overall Success (Result Sustainability)	0.337	0.002	0.337	0.007
Result Sustainability (Overall Success)	0.337	0.006	0.337	0.007
Overall Success (Work Area Attitude and Commitment)	0.432	<.0001	0.432	<.0001
Work Area Attitude and Commitment (Overall Success)	0.388	<.0001	0.432	<.0001

In summary, the correlation findings found that there was at least marginal support for all relationships except *work area attitude and commitment* and *result sustainability*, which is clearly not significant. A summary of all of the correlation findings based on the adjusted alpha value ($\alpha = 0.005$) are as follows:

- The technical system outcomes, *goal sustainability, result sustainability*, and *impact on area-T1* were significantly correlated with one another at the adjusted alpha value. *Overall success* was also significantly correlated with all of the technical system outcomes at the adjusted alpha level except *result sustainability*; the p-value from the correlation of *overall success* and *result sustainability* was only slightly higher than the adjusted alpha level (0.006).

- The social system outcome *work area attitude and commitment* and the perceptual technical system outcomes, *impact on area-T1* and *overall success* were significantly correlated with one another at the adjusted alpha value.

- There was marginal support for the correlation of *work area attitude and commitment* and *goal sustainability* (p=0.017). The correlation of *work area attitude and commitment* and *result sustainability* was not significant (p=0.168).

4.7 Post-Hoc Analyses: Alternative Models of Result Sustainability and Goal Sustainability
Because both the *result sustainability* and *goal sustainability* models explained less variation than anticipated, an alternative model of these variables of interest were explored. In particular, the researchers were interested in examining the subset of the total number of events that were implementation events and also reported the results for at least one primary goal objectively, i.e.,

T0 and T1 results reported objectively. Twenty-three events fit these criteria. Organization. A accounted for 12 of the 23 events, Organization E accounted for 5 of the 23 events and Organization Q accounted for 3 of the 23 events. Organizations B, G, and R accounted for 1 of the 23 events each.

For *result sustainability*, nine of the 23 events had a value greater than or equal to 100%. For *goal sustainability*, sixteen of the 23 events had a value greater than or equal to 100%.

In order to determine which factors were significant within this subset, two approaches were taken:

- The variables that were found to be significant in the full dataset (n=65) in both the multiple linear regression and logistic regression models were tested with the subset of events (n=23). The testing that was performed on the subset of events was done using OLS. GEE was not used because some organizations only had one event in the subset.

- A series of methods adapted from Van Aken (1995) were employed. First, bivariate correlations were calculated with each outcome for all independent variable. Next, the variables that had a significant bivariate correlation with the outcome were further analyzed via partial correlation analysis. Finally, the variables that had a significant partial correlation with the outcome were tested using regression modeling.

4.7.1 Result Sustainability-Modeling Approach One

The one-variable solution found in the full dataset for the continuous measure of *result sustainability* was no longer significant in the subset of implementation only events with objective results (n=23; see Table 52).

Table 52. Regression Model of Result Sustainability (n=23): Continuous Variable

	OLS β	SE OLS β	α OLS
Intercept	1.210	0.420	0.009
Improvement culture	-0.038	0.090	0.677
OLS R^2 = 0.0084; OLS R_a^2 = -0.039, F1, 21= 0.18			

The four-variable solution found in the full dataset for the binary measure of *result sustainability* was also not significant in the subset of implementation-only events with objective results (n=23; see Table 53).

Table 53. Logistic Regression Model for Result Sustainability (n=23)

	OLS β	SE OLS β	α OLS
Intercept	-0.272	4.479	0.952
Performance Review	0.026	0.532	0.117
Learning and Stewardship	2.263	1.628	0.164
Experimentation and Continuous Improvement	-2.488	1.589	0.117
Event Planning Process	0.492	1.263	0.697
WLS R^2 = 0.308 (Negelkerke); WLS χ^2 (4)= 5.707			

4.7.2 Result Sustainability-Modeling Approach Two

First, the bivariate correlations of result sustainability with all of the independent variables were calculated. The bivariate correlations show that none of the variables were significantly correlated with the continuous measure of *result sustainability* (Table 52). However, two variables, *production system changes* (Kendall's tau and Spearman's rho) and *team functional heterogeneity* (Pearson correlation coefficient) that had with p-values < 0.1, which may be meaningful given the small size of the subset. The bivariate correlations of the binary measure of result sustainability show that *production system changes* is the only significantly correlated variable (Table 55).

Table 54. Bivariate Correlations of the Result Sustainability Measure of Implementation Events with Objective Results Only: Continuous Variable

	Pearson		Kendall's tau_b		Spearman's rho	
	Correlation Coefficient	Sig. (2-tailed)	Correlation Coefficient	Sig. (2-tailed)	Correlation Coefficient	Sig. (2-tailed)
Goal Clarity	-.329	.169	-.234	.170	-.327	.172

Goal Difficulty	.203	.405	-.084	.622	-.049	.841
Team Functional Heterogeneity	.395	.094	.273	.117	.350	.142
Management Support	-.009	.970	-.024	.888	-.011	.963
Work Area Routineness	.186	.447	.207	.248	.258	.287
Institutionalizing Change	.167	.494	.018	.916	-.018	.943
Improvement Culture	.003	.992	-.113	.520	-.116	.635
Performance Review	.238	.325	.173	.319	.240	.322
Avoiding Blame	-.252	.299	-.274	.134	-.354	.137
Management Change	.175	.474	.207	.300	.244	.313
Production System Changes	.153	.531	.344	.076	.425	.069
Employee Change Ratio	-.026	.915	-.041	.823	-.042	.865
Learning and Stewardship	-.030	.905	.107	.542	.099	.688
Experimentation and Continuous Improvement	-.162	.508	-.208	.246	-.280	.245

Table 55. Bivariate Correlations of the Result Sustainability Measure of Implementation Events with Objective Results Only: Binary Variable

	Kendall's tau_b		Spearman's rho	
	Correlation Coefficient	Sig. (2-tailed)	Correlation Coefficient	Sig. (2-tailed)
Goal Clarity	-.123	.535	-.146	.551
Goal Difficulty	.025	.901	.029	.906
Team Functional Heterogeneity	.127	.532	.147	.547

Management Support	.066	.741	.078	.751
Work Area Routineness	.186	.375	.209	.390
Institutionalizing Change	.082	.679	.097	.691
Improvement Culture	.137	.503	.158	.519
Performance Review	.288	.156	.334	.162
Avoiding Blame	-.263	.220	-.289	.230
Management Change	.136	.563	.136	.578
Production System Changes	.563*	.014	.582**	.009
Employee Change	.296	.162	.330	.168
Learning and Stewardship	.242	.239	.277	.250
Experimentation and Continuous Improvement	-.213	.309	-.240	.323
*Correlation is significant at the 0.05 level (2-tailed).				
**Correlation is significant at the 0.01 level (2-tailed).				

Because only one variable was found to be significant, the second step, to calculate the partial correlations controlling for other independent variables, was not needed. Therefore, the third step, to perform the regression modeling was completed. The results of the regression modeling, are presented in Table 56. *Production system changes* is significant at the 0.05 level, suggesting that a greater amount of changes in a work area may increase the likelihood that results are sustained.

Table 56. Logistic Regression Model for Result Sustainability and Production System Changes (n=23)

	OLS β	SE OLS β	α OLS
Intercept	-1.225	0.657	0.062
Production system changes	2.458	1.212	0.043
WLS R^2 = 0.424 (Negelkerke); WLS χ^2 (1)= 7.207**			

4.7.3 Goal Sustainability-Modeling Approach One

The one-variable solution found in the full dataset for the continuous measure of *goal sustainability* was no longer significant in the subset of implementation only events with objective results (n=23; see Table 57).

Table 57. Results for Goal Sustainability (n=23): Continuous Variable

	OLS β	SE OLS β	α OLS
Intercept	0.244	0.523	0.646
Learning and stewardship	0.150	0.108	0.182
OLS R^2 = 0.0831; OLS R_a^2 = 0.039, F1, 21= 1.90			

4.7.4 Goal Sustainability-Modeling Approach Two

First, the bivariate correlations of goal sustainability with all of the independent variables were calculated. The bivariate correlations show that one variable, *performance review*, was significantly correlated with the continuous measure of *goal sustainability* (Table 58). The bivariate correlations of the binary measure of goal sustainability show that none of the variables were significantly correlated (Table 59).

Table 58. Bivariate Correlations of the Goal Sustainability Measure of Implementation Events with Objective Results Only: Continuous Variable

	Pearson		Kendall's tau_b		Spearman's rho	
	Correlation Coefficient	Sig. (2-tailed)	Correlation Coefficient	Sig. (2-tailed)	Correlation Coefficient	Sig. (2-tailed)
Goal Clarity	.080	.745	.073	.683	.105	.669
Goal Difficulty	.258	.285	.132	.457	.162	.507
Team Functional Heterogeneity	.208	.394	-.068	.707	-.119	.628
Management Support	.185	.448	.259	.147	.319	.184
Work Area	.139	.570	.000	1.000	-.014	.954

Routineness						
Institutionalizing Change	.226	.351	.113	.527	.169	.489
Improvement Culture	.330	.168	.326	.077	.430	.066
Performance Review	.540[*]	.017	.383[*]	.035	.464[*]	.046
Avoiding Blame	.059	.810	.068	.722	.084	.734
Management Change	-.132	.590	-.147	.485	-.165	.501
Production System Changes	.112	.647	-.019	.927	-.025	.919
Employee Change Ratio	.028	.909	.127	.503	.207	.395
Learning and Stewardship	.357	.133	.161	.384	.211	.385
Experimentation and Continuous Improvement	.241	.320	.230	.222	.295	.220
*Correlation is significant at the 0.05 level (2-tailed).						
**Correlation is significant at the 0.01 level (2-tailed).						

Table 59. Bivariate Correlations of the Goal Sustainability Measure of Implementation Events with Objective Results Only: Binary Variable

	Kendall's tau_b		Spearman's rho	
	Correlation Coefficient	Sig. (2-tailed)	Correlation Coefficient	Sig. (2-tailed)
Goal Clarity	.078	.693	.093	.705
Goal Difficulty	.017	.930	.021	.933
Team Functional Heterogeneity	-.207	.308	-.240	.322
Management Support	.245	.219	.290	.229
Work Area Routineness	.028	.893	.032	.897
Institutionalizing Change	-.131	.510	-.155	.525

Improvement Culture	.237	.248	.272	.260
Performance Review	.162	.425	.188	.441
Avoiding Blame	.169	.429	.186	.445
Management Change	.121	.609	.121	.623
Production System Changes	.024	.915	.025	.918
Employee Change	.049	.817	.055	.824
Learning and Stewardship	.119	.562	.137	.577
Experimentation and Continuous Improvement	.274	.192	.308	.200

*Correlation is significant at the 0.05 level (2-tailed).

**Correlation is significant at the 0.01 level (2-tailed).

Because only one variable was found to be significant, the second step, to calculate the partial correlations controlling for other independent variables, was not needed. Therefore, the third step, to perform the regression modeling was completed. The results of the regression modeling, using both the OLS and GEE model-based estimates are presented in Table 60. Performance review significant at the 0.05 level and the R^2 =0.180, suggesting that performance review activities may increase the likelihood that goals are sustained.

Table 60. Regression Model for Goal Sustainability-Continuous Variable and Performance Review (n=23)

	GEEβ	SE GEE β	α GEE	OLSβ	SE OLSβ	α OLS
Intercept	0.514	0.200	0.010	0.551	0.206	0.015
Performance Review	0.121	0.049	0.015	0.108	0.051	0.049
OLS R^2 = 0.180, OLS R_a^2 = 0.139, F1, 20= 4.39*						

4.9 Summary of Results of Hypothesis Tests

Table 61 summarizes the results of the tests of H1-H5.

Table 61. Summary of Results of Research Hypothesis Tests

Hypothesis	Findings	Overall Conclusion
H1. Kaizen Event Characteristics are positively related to Sustainability Outcomes at the team level. H0. Kaizen Event Characteristics are not positively related to Sustainability Outcomes at the team level.	• For *result sustainability*, post-hoc Kaizen Event Characteristic *event planning process* was a significant, positive direct predictor • No Kaizen Event Characteristics were significant direct predictors of *work area attitude and commitment*, *impact on area-T1*, *goal sustainability*, or *overall success*	Partially Supported
H2. Work Area Characteristics are positively related to Sustainability Outcomes at the team level. H0. Work Area Characteristics are not positively related to Sustainability Outcomes at the team level.	• For *work area attitude and commitment*, *experimentation and continuous improvement* was a significant, positive direct predictor. • For *result sustainability*, *learning and stewardship* was a significant positive direct predictor and *experimentation and continuous improvement* was a significant negative direct predictor • No Work Area Characteristics were significant direct predictors of *impact on area-T1, goal sustainability,* or *overall success*	Partially Supported
H3. Post-Event Characteristics are positively related to Sustainability Outcomes at the team level. H0. Post-Event Characteristics are not positively related to Sustainability Outcomes at the team level.	• For *work area attitude and commitment*, *performance review* and post-hoc Post-Event Characteristic *accepting changes* were significant, positive direct predictors. • For *impact on area-T1*, *accepting changes* were significant, positive direct predictors. • For *result sustainability*, *performance review* was a significant, negative direct predictor. • For *overall success*, *accepting changes* was a significant, negative direct predictor. • No Post-Event Characteristics were significant direct predictors of *goal*	Partially Supported

	sustainability	
H4. Post-Event Characteristics partially mediate the relationship of Kaizen Event Characteristics and Sustainability Outcomes. H_0. Post-Event Characteristics do not mediate the relationship of Kaizen Event Characteristics and Sustainability Outcomes.	• For *work area attitude and commitment*, *performance review* fully mediates *work area routineness*. • Post-Event Characteristics did not mediate the relationship between the Kaizen Event Characteristics and *impact on area-T1*, *result sustainability*, or *overall success*.	Partially Supported
H5. Post-Event Characteristics partially mediate the relationship of Work Area Characteristics and Sustainability Outcomes. H_0. Post-Event Characteristics do not mediate the relationship of Work Area Characteristics and Sustainability Outcomes.	• For *work area attitude and commitment*, *performance review* fully mediates *learning and stewardship*. • For *work area attitude and commitment*, *accepting changes* fully mediates *production system changes* and partially mediates *experimentation and continuous improvement*. • For *impact on area-T1*, *accepting changes* partially mediates *learning and stewardship*. • For *overall success*, *accepting changes* partially mediates *learning and stewardship*.	Partially Supported

CHAPTER 5: DISCUSSION

This chapter provides discussion and interpretation of the research results, specifically, regarding the direct and indirect relationships tested through the regression modeling of each Sustainability Outcome: *work area attitude and commitment, impact on area-T1*, *result sustainability*, and *overall success*. Because the model of *goal sustainability* failed to exhibit any direct predictors, the resulting model cannot be interpreted. However, a discussion of the measurement concerns that may have impacted the *goal sustainability* and *result sustainability* models and the *goal sustainability* findings from the post-hoc analysis alternative modeling (Section 4.7) as they relate to the the measurement concerns and the model of *result sustainability* are presented.

In the discussion of each Sustainability Outcome, the following is presented:

- A figure of each Sustainability Outcome's significant predictors as reported in Chapter 4 along with the corresponding GEE regression coefficients for each predictor. Some direct or indirect predictors (e.g., nominal 0-3 index of *production system changes*) are measured on a different scale than others (e.g., six-point Likert-scale of *accepting changes*), therefore, the corresponding coefficients in the models are not directly comparable, as the GEE regression coefficients are unstandardized. Finally, the mediation coefficients are raw, unmoderated estimates. The mediator regression coefficient in the direct effects model was usually smaller than the coefficient in the mediation model because the mediation model contained only the mediator, mediated variable and the dependent variable, not the other direct predictors of the outcome. Therefore, the mediation coefficients likely represent an upper bound of the actual mediated effect.

- The relevant literature that further explains the model for each outcome.

- Extreme case sampling (Yin, 1994) of the events having the highest and lowest values for the outcome variable in order to present additional qualitative observations. These interpretations are not intended to be conclusive or generalizable because they only consider a subset of the total sample, but, rather, are intended to provide additional detail that may support the study findings.

- A comparison of the current research findings with the findings of the first phase of the OSU-VT research (Farris, 2006; Farris et al., 2009) to identify similarities and differences between related outcomes.

Lastly, the chapter concludes with discussion of the limitations of the present research.

5.1 Predictors of Work Area Attitude and Commitment

This research found that the most significant predictors of *work area attitude and commitment* toward Kaizen events were *experimentation and continuous improvement* (direct and indirect positive), *performance review* (direct positive), *accepting changes* (direct positive), *work area routineness* (indirect positive), *learning and stewardship* (indirect positive), and *production system changes* (indirect positive). The direct predictors of *work area attitude and commitment* toward Kaizen events explained approximately 50% of the variance (GEE $R^2 = 0.5026$). Figure 11 illustrates the direct and indirect predictors and their relative effect sizes on *work area attitude and commitment.*
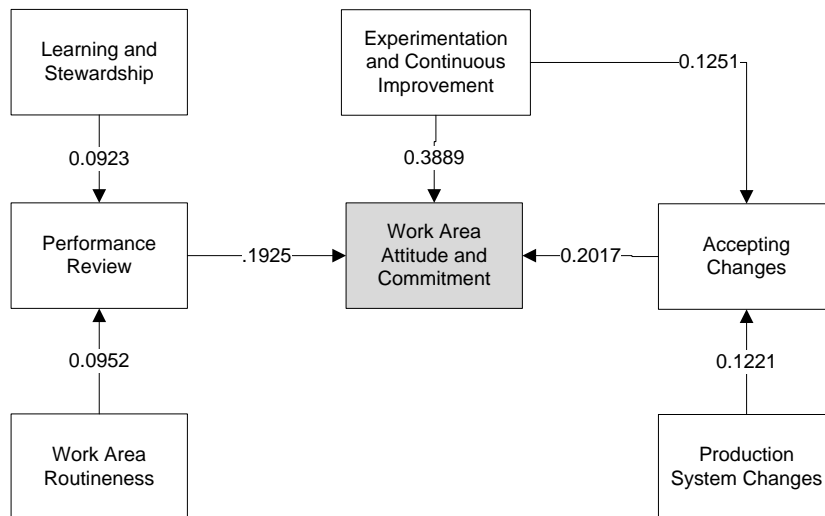
Figure 11. Work Area Attitude and Commitment Model

5.1.1 Literature Support of Work Area Attitude and Commitment Model

Work area attitude and commitment was found to be positively related to the Work Area Characteristic *experimentation and continuous improvement*. Experimentation relates to the

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degree to which work area employees try new things through application to aid in learning (Groesbeck, 2001) while continuous improvement relates to the degree to which work area employees understand the continuous improvement philosophy and their role in continuous improvement (Doolen et al., 2003). Experimentation and continuous improvement activities are both identified as action-oriented learning behaviors (Yeung et al., 1999). The inclusion of *experimentation and continuous improvement* as a predictor of *work area attitude and commitment* is supported by previous studies that have suggested that direct employee participation in designing changes may create employee buy-in to a lean manufacturing program (Bradley and Willett, 2004; Melnyk et al., 1998; Tanner and Roncarti, 1994). This finding is also supported by previous studies that have suggested that employees' understanding of the benefits of improvement for themselves, supported by participation in continuous improvement activities, is essential to sustaining improvement efforts (e.g., Keating et al., 1999). Also, understanding of continuous improvement by work area employees has been found to support a continuous improvement culture (Kaye and Anderson, 1999). Practically, this finding suggests that after a Kaizen event, work area managers may influence work area employees' attitude and commitment toward Kaizen events by encouraging active experimentation in the work area and fostering an understanding of continuous improvement.

Work area attitude and commitment was also found to be positively related to the Post-Event Characteristic, *performance review*. This finding suggests work area employees' attitudes and commitment toward Kaizen events may be increased by management after a Kaizen event through the establishment of activities such as reviewing work area performance measures, conducting audits, and holding meetings with leadership (including higher-level management) regarding the Kaizen event progress or follow-up. Although previous research has not specifically related *performance review* activities to human resource outcomes, in general, previous research has suggested that the use of measurement systems and activities may prevent the deterioration of process-related improvements over time (Bateman and Rich, 2003; Kaye and Anderson, 1999; Dale et al., 1997). Furthermore, *performance review* activities may increase the visibility for changes in general, and thus employee awareness of change specifically, which has been suggested to create employee buy-in to a lean manufacturing program (Bradley and Willett, 2004; Melnyk et al., 1998; Tanner and Roncarti, 1994). For example, if regular audits and meetings about Kaizen event progress are conducted in the work area, work area employees may

be more likely to be aware of such activities which may influence their attitude and commitment toward Kaizen events.

Performance review was also found to be a mediating variable in the work area attitude and commitment model, which presents additional ways to influence the use of performance review activities. The mediation analysis found that learning and stewardship was positively, indirectly related to work area attitude and commitment through performance review, which suggests that performance review of a Kaizen event may be present to a greater extent in work areas that encourage learning and stewardship among their employees. A majority of the related performance review literature focuses on the influence that performance review systems may have on organizational learning and stewardship (e.g. Kloot, 1997; Mausloff and Spence, 2008) as opposed presence of the reverse relationship. For example, Kloot (1997) notes that a performance measurement system that places more responsibility for control on its work area employees may foster a greater sense of responsibility and accountability among them. However, based on the present research findings, the relationship between performance review activities and learning and stewardship appears to be a dynamic one such that these variables may reinforce one another. Kaye and Anderson (1999) allude to this dynamic relationship as they viewed performance review activities such as regular project briefings with management and employees as group learning experiences because they served as a platform to share experiences and progress on projects. Furthermore, it should be noted that the mediation results only test correlation, not causality (Hardin and Hilbe, 2003; Kenny, 2009); therefore, it is possible that the actual direction of the relationship is reversed. Thus, practitioners may wish to encourage learning and stewardship among work area employees (e.g., sharing information in the work area and fostering a shared sense of responsibility) as it may influence more formal mechanisms of learning and accountability, i.e., the performance review activities. As presented in Section 4.2.2, a caveat to this finding is that learning and stewardship may only be marginally indirectly related to work area attitude and commitment through performance review because the p-value (0.0295) was greater than the adjusted α level (0.0167).

The mediation analysis also found that work area routineness was positively, indirectly related to work area attitude and commitment through performance review, which suggests that performance review activities may be more easily performed in less complex work areas. Generally, it is recognized that performance measurement may be more difficult to perform in

complex work systems, oftentimes due to difficulties in defining performance measures (e.g., Beamon, 1999). Furthermore, it may be difficult to interpret and compare results from defined performance measures in more complex systems due to greater variability in performance (e.g., Martin and Smith, 2005). Thus, it stands to reason that managers guiding more complex work areas may face a disadvantage in terms of conducting *performance review* activities due to a lack of the necessary information (performance data, etc.) and these managers may wish to focus on other areas in order to influence *work area attitude and commitment*, e.g., *learning and stewardship,* that may offset this potential disadvantage.

Post-hoc analysis found that the Post-Event Characteristic *accepting changes* was positively related to *work area attitude and commitment*. This finding suggests that, after a Kaizen event, perceptions of work area employees' attitudes and commitment toward Kaizen events may be increased through mechanisms used to reinforce work area employee and management's acceptance of the changes as a result of the Kaizen event. These mechanisms may include work area employees adhering to new work methods and management holding employees accountable for following the new work methods. Although previous research has not specifically related *accepting changes* to human resource outcomes, the relationship appears to have face validity; in other words, as work area employees' increase their acceptance of changes resulting from the Kaizen event, it seems likely that their belief in the value and need for Kaizen events would also increase. Furthermore, previous research has suggested that concepts and activities related to *accepting changes* may support the sustainability of change. For example, management's reinforcement of continuous improvement by regularly checking and raising the continuous improvement awareness and understanding of employees has been identified as an essential criterion for creating a continuous improvement culture (Kaye and Anderson, 1999). Also, it appears to be logical that the acceptance of procedurally-related changes (e.g., following new work methods) would foster the development of the development of a culture with attitudes that are "open-minded," exhibit "enthusiasm" and "positive" such a culture has been found to be an enabler of improvement sustainability (Bateman and Rich, 2003).

Accepting changes was found to be a mediating variable in the *work area attitude and commitment,* which presents additional ways to influence *accepting changes*. The mediation analysis found that *experimentation and continuous improvement* was positively, indirectly related to *work area attitude and commitment* through *accepting changes* which suggests that the

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acceptance of change, follow-through of changes, and accountability for change may be present to a greater extent in work areas that exhibit higher levels of *experimentation and continuous improvement* among their employees. These findings are supported by the work of Keating et al. (1999) which found that the workforce's participation in continuous improvement activities supports employees' acceptance and understanding of changes. Also, it appears to be likely that work area employees that have increased involvement in direct learning behaviors such as *experimentation and continuous improvement* may be more accepting of change as they may be more accustomed to trying new concepts and testing new ideas in the work area. Therefore, managers may wish to influence *accepting changes* made as a result of a Kaizen event through the use of direct experimentation and understanding of continuous improvement among work area employees.

The mediation analysis also found that *production system changes* was positively, indirectly related to *work area attitude and commitment* through *accepting changes* which suggests that *accepting changes* activities may be more easily performed in work areas that have experienced more volume, product mix, and/or equipment changes. The dataset shows that Organization A experienced *production system changes* most frequently with at least one production related change in eight targeted work areas; Organization A also had the highest average of *accepting changes*. It is interesting that both *experimentation and continuous improvement* and *production system changes* were related to *accepting changes* because previous research has found that experimentation and continuous improvement learning styles are more prevalent in organizations that effectively use a flexible product differentiation strategy (Yeung et al., 1999). Thus organizations with more flexible production capabilities, i.e., organizations that can easily adapt to changes in product mix, etc., may be more likely to use learning strategies that encourage change and may also be more accepting of other changes, including those resulting from a Kaizen event.

Alternatively, as presented by the potentially confounding effect identified in the mediation analysis (Section 4.6.1), the indirect influence of *production system changes* on *work area attitude and commitment* may be accentuated because *accepting changes* may have explained variability in *production system changes* (or vice versa). In other words, the *production system changes* may have required the acceptance of changes as a result of the Kaizen event. This possibility is illustrated in some of the Kaizen events studied. For example,

the goal of event 523 was to implement a new layout of a designated work area to accommodate an incoming piece equipment. In this example, the acceptance of the change made as a result of the Kaizen event, i.e., the new layout, is closely related to the production system change, i.e., the new equipment, such that the chance that *accepting changes* may be explaining variability within *production system changes* seems possible.

5.1.2 Observation of Events with Highest and Lowest Work Area Attitude and Commitment Values

To provide further explanation of the research results, the events with the highest and lowest values for each outcome variable were identified and further analyzed. Events with the five highest values for *work area attitude and commitment* occurred in Organization A, a secondary wood products manufacturer. The *work area attitude and commitment* values of these events were 5.5 or higher (Table 62), indicating that higher levels of work area employees' attitudes toward and belief in the value of Kaizen events were found.. For this subset of events, the strongest predictor of *work area attitude and commitment*, *accepting changes,* also had very high values that ranged between 5.5 and 6.0 (average 5.9), suggesting that there were higher levels of change acceptance in the work area across all of these events. The *experimentation and continuous improvement* values for these events ranged from 4.75 to 5.75 (average 4.95), suggesting that there were moderate to high levels of experimentation in the work areas and that continuous improvement was understood among the work area employees across these events. There was more variation across the values for *performance review* for these events, which ranged from 3.0 to 5.6 (average 4.36); this may be explained by the fact that *performance review* was the weakest predictor in the model.

Events with the five lowest responses for *work area attitude and commitment* occurred in Organizations E (specialty equipment manufacturer), F (steel component manufacturer), Q (IT component manufacturer, and G (aerospace engineering and manufacturer). Their *work area attitude and commitment* values were all less than 3.2 (Table 46), suggesting that there were lower levels of attitude and commitment of their work area employees toward Kaizen events since the Kaizen event. Not all of the Kaizen events had low values for each predictor. However, the average value of each predictor was noticeably lower across the subset of events and there was clearly greater variation for predictor values across the subset of events when

compared to the subset of events with the highest *work area attitude and commitment* values. *Accepting changes* ranged from 1.0 to 5.0 (average 3.25), *experimentation and continuous improvement* values ranged from 2.5 to 4.5 (average 3.50), and *performance review* values ranged from 1.2 to 4.6 (average 2.6).

Another difference between the events with the highest and lowest *work area attitude and commitment* values was the number of implementation versus non-implementation events. Events were categorized as non-implementation events if the T0 results were presented as "to be determined," or if the T0 results were presented as projected results that were expected to be achieved if the future state for the work area that was defined during the Kaizen event was implemented (see Section 3.1.1). All of the events with the highest *work area attitude and commitment* responses were implementation-oriented events while only two of the five events with the lowest *work area attitude and commitment* values were implementation-oriented events. This anecdotally suggests that the implementation-orientation of an event may provide additional understanding of *work area attitude and commitment*. In other words, employees in the targeted work area of an implementation event may have increased attitudes and commitment toward Kaizen events when compared to the employees in the targeted work area of a non-implementation event. Similar to the role of *experimentation and continuous improvement* in the model, this proposition is aligned with previous studies that have found that direct employee participation in designing changes may create employee buy-in to a lean manufacturing program (Bradley and Willett, 2004; Melnyk et al., 1998; Tanner and Roncarti, 1994). Also, the values for each predictor generally had higher values for the subset of events with the highest *work area attitude and commitment* values compared to the subset of events with the lowest *work area attitude and commitment* values. This observation supports the regression findings that all of the predictors of *work area attitude and commitment* were positive.

An examination of the primary goals of the events with the highest and lowest *work area attitude and commitment* values also provides insight into the regression findings. The primary goals of four of the five teams with the highest *work area attitude and commitment* values were related to standardizing work. Standard work techniques often include the integration of best practices, updating documentation, and implementing visual cues; these techniques have been suggested to assist employees with sustaining the improvements (Martin, 2007). The targeted activities of these events also appear to support *accepting changes*. For example, through the

implementation of standard work documentation and visual cues, work area employees may be more likely to follow the new work methods. The events also usually included the adoption of an auditing or inspection process. Such activities are related to *performance review,* which was found to be positively related to *work area attitude and commitment*.

Four of the five teams with the lowest *work area attitude and commitment* values had primary goals that were related to addressing quality issues, including the reduction of errors and testing failures. As presented earlier, the work of Kaye and Anderson (1999) identifies ten essential criteria to continuous improvement of quality management efforts that may provide some insight as to why these cases may have experienced lower perceptions of work area employee attitudes and commitment toward Kaizen events. In efforts to improve quality in an organization, Kaye and Anderson (1999) emphasize the importance of performance review activities as well as the importance of direct employee participation in improvement efforts and employee understanding of quality and continuous improvement. However, the cases with the lowest *work area attitude and commitment* had, on average, lower values of *performance review* and *experimentation and continuous improvement.*

Also, Kaye and Anderson (1999) note that management should avoid blame when addressing quality issues (e.g., mistakes). It is possible that because these events addressed work mistakes, i.e., errors and defects, work area employees may relate Kaizen events to the identification of mistakes; furthermore, if additional supportive structures were not present, work area employees may tend to develop negative attitudes toward Kaizen events. Interestingly, an event with one of the highest *work area attitude and commitment* values was also related to scrap reduction. However, it is possible that because the overall organization (Organization A) has conducted other events that emphasized activities such as *accepting changes* and *performance review*, the work area employees may have been more receptive to the changes and more prepared to address quality concerns.

These observations suggest that managers may find it beneficial to have standard work events, e.g., using a standard work event to implement techniques that may enhance the acceptance of change and following new work methods, as they may help to support the critical factors of *work area attitude and commitment*. In addition, managers may wish to place additional emphasis on those critical factors when using Kaizen events to address quality issues.

Table 62. Events with the Highest and Lowest Work Area Attitude and Commitment Values

Org	Event	Primary Goals of the Event	Attitude and Comm.	Acc. Changes	Exp. and CI	Perf. Review
— Events with Highest Work Area Attitude and Commitment Values						
A	505	Standardize the equipment lubrication process, including establishing and posting standards	5.83	6.00	5.75	3.20
A	547	Total production maintenance event; implemented inspections	5.83	6.00	4.75	4.60
A	514	Standardize the equipment lubrication process, including establishing and posting standards	5.67	6.00	4.75	3.00
A	502	Identified areas creating scrap and improved the areas to reduce scrap	5.50	5.50	4.75	5.40
A	550	7 Principles of warehousing: Updated the inventory to reflect the current production mix	5.50	6.00	4.75	5.60
Events with Lowest Work Area Attitude and Commitment Values						
Org	Event	Primary Goals of the Event	Attitude and Comm.	Acc. Changes	Exp. and CI	Perf. Review
G	1807	Create guidelines for product installation process and improve supplier and internal quality	3.17	5.00	3.25	1.20
E	114	Streamline process and reduce errors and omissions.	3.00	1.00	2.50	2.20
G	1804	Event explored ways to reduce test failures and refine test equipment	3.00	5.00	4.50	4.60
F	400	Evaluating and moving inventory from one building to another building	2.83	3.00	3.75	2.60
Q	1700	Decrease waste in work area by reducing lead time variability, throughput, operator travel, etc.	2.67	4.25	3.50	2.40

5.1.3 Comparison of Work Area Attitude and Commitment to Attitude (Phase One of OSU-VT Research)

In this section, predictors of *work area attitude and commitment* are compared to the critical factors of team member *attitude* toward Kaizen events found during the first phase of the OSU-VT research. A*ttitude* toward events was positively related to *management support* and *internal processes* (a measure of team harmony) and negatively related to *team functional heterogeneity* (an index measuring the cross-functional diversity of the team) (Farris, 2006; Farris et al., 2009).   There are differences between the first phase findings and the current findings.   For example, *team functional heterogeneity* was important to the immediate achievement of increased attitudes (T0), but it was not a factor in the study of the work area at T1. This difference is not particularly remarkable as one may expect that the characteristics of

the work area may have more influence over Sustainability Outcomes, particularly the human resource outcomes, than the characteristics of the temporary improvement team.

One similarity between the first phase findings and the present research is the apparent importance of the role of employee internal processes and group norms. The first phase of the OSU-VT research found that *internal processes* (team harmony) was a critical factor of the Kaizen event team's *attitude* toward Kaizen events. While the present research did not directly measure the internal processes of the work area, it did find that *experimentation and continuous improvement* and *accepting changes* were critical factors of *work area attitude and commitment*. Both of these factors relate to group normative behaviors or psychosocial traits of the work area which are related to the internal processes of a group (Cohen and Bailey, 1997). This similarity suggests that characteristic processes and behaviors of employees may influence attitudes both during the Kaizen event (i.e., having a harmonious team) and after the Kaizen event (e.g., accepting and following changes).

Another similarity between the first phase findings and the present research is the apparent importance of the role of management. The first phase of the OSU-VT research found that *management support* was a critical factor of the Kaizen event team's *attitude* toward Kaizen events and the present research found that *accepting changes*, which includes management's acceptance and reinforcement of change, was a critical factor of *work area attitude and commitment*. This similarity suggests that management can influence attitudes both during the Kaizen event (i.e., providing resources) and after the Kaizen event (i.e., accepting changes and holding employees accountable for following changes).

5.2 Predictors of Impact on Area-T1

Through post-hoc analysis, the research found that the most significant predictors of *impact on area-T1*, were *accepting changes* (direct positive) and *learning and stewardship* (indirect positive). The direct predictor explained approximately 50% of the variance (Figure 12).
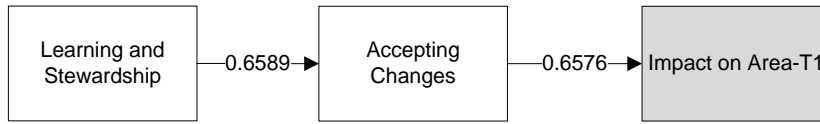
Figure 12. Impact on Area-T1 Model

5.2.1 Literature Support of Impact on Area-T1 Model

Impact on area-T1 describes perceptions of the impact of the Kaizen event on the target system, including the extent to which:

- the Kaizen event had a positive effect on the work area,
- the Kaizen event improved the performance of the work area, and
- the work area improved measurably as a result of the Kaizen event.

As discussed in Chapter 2, changes as a result of Kaizen events have been reported to immediately improve performance in a variety of ways, including increased productivity, reduced cycle time, and decreased WIP (Laraia et al., 1999). The extent to which such changes have a lasting impact on the work area is a criterion of change institutionalization (Buller and McEvoy, 1989). Therefore, a practical implication of this research is that by studying the perceptions of *impact on area-T1*, managers may better understand the extent to which Kaizen events are able to make a lasting measurable improvement on performance and what factors may influence *impact on area-T1*. The average *impact on area-T1* was 4.55 and suggests that, on average, the respondents reported moderate levels of impact on the targeted work area from the Kaizen event.

Based on the initially hypothesized set of potential predictors, *avoiding blame*, a Post-Event Characteristic, and *work area routineness*, a Kaizen Event Characteristic, were found to be significant predictors of *impact on area-T1* (Section 4.3). However, post-hoc analysis found that the Post-Event Characteristic *accepting changes* was positively related to *impact on area-T1*. The adoption of the post-hoc model was statistically supported because when *accepting changes* was added to the model, the independent variables from the initial model, *avoiding blame* and *work area routineness,* were not significant. Furthermore, the model including *accepting changes* explained a greater amount of variance (approximately 25% of additional variance) than the initial model including only *avoiding blame* and *work area routineness* (see Section 4.6.2).

Therefore, the post-hoc model of *impact on area-T1* was adopted. However, future research may wish to consider the potential influence that *avoiding blame* and *work area routineness* may have on *impact on area-T1*.

The significant relationship between *accepting changes* and *impact on area-T1* implies that managers may increase the perceived impact of a Kaizen event on the targeted work area through increasing the extent to which the employees follow new work methods, increasing the extent to which the workforce and management accept changes, and increasing the extent to which management holds employees accountable for following those new work methods. As discussed earlier for the outcome *work area attitude and commitment*, previous research has suggested that perceptions and activities related to *accepting changes,* including having an "open-minded" workforce (Bateman and Rich, 2003) and the reinforcement of change from management (Kaye and Anderson, 1999), relate to a work area or organizational culture that supports sustainable improvements which provides general support for this finding. More specific support for the significant relationship between *accepting changes* and *impact on area-T1* is also evident in the literature. For example, the first follow-up task in Bateman and Rich's (2002) model of improvement sustainability is "maintaining the new procedure." This task is similar to the component of *accepting changes* that refers to the extent to which work area employees follow the new work methods as a result of the Kaizen event.

Mediation analysis found that *learning and stewardship* was positively, indirectly related to *impact on area-T1* through *accepting changes* which suggests that higher perceptions of *accepting changes* activities may be evident in work areas that encourage *learning and stewardship* among their employees. As discussed earlier, *learning and stewardship* relates to the extent to which work area employees collaborate with their peers, have an external perspective of how their work fits in the larger organization, and have a sense of stewardship, or shared responsibility for the overall organization. Researchers note that a learning-oriented workforce may be more open-minded about the way work is performed (Baker and Sinkula, 1999) and may have increased feelings of ownership over the changes that are implemented in their work area (Oxtoby et al., 2002). Therefore, it appears that work area employees that have increased *learning and stewardship* may be more accepting of change because they may be more aware of the role that their acceptance may play in the larger organization and wish to be 'good stewards' by accepting and following the change. Therefore, a practical recommendation for

managers is to promote internal collaborative learning, the development of an external perspective, and stewardship among work area employees in order to influence greater acceptance of change.

5.2.2 Observation of Events with Highest and Lowest Impact on Area-T1 Values

In order to provide further explanation of the research results, additional observation of the events with the highest and lowest values for each outcome variable was conducted. Events with the highest responses for *impact on area-T1* occurred in Organization A and Organization R (Table 63). The *impact on area-T1* value for each of the seven events was 6.0, suggesting that the Kaizen event highly impacted the targeted work area. For this subset of events, *accepting changes* had very high values (5.25-6.0), suggesting that there were higher levels of acceptance of changes in the work area across all these events.

Events with the lowest responses for *impact on area-T1* occurred across six of the eight organizations. The *impact on area-T1* values for this subset of events were all less than 3.0, suggesting that there were lower levels of impact on the targeted work area from the Kaizen event. The average value of *accepting changes* was noticeably lower across this subset of events and there was clearly greater variation as *accepting changes* ranged from 1.0 to 5.0 (average 3.0).

Comparing events with the highest and lowest *impact on area-T1* values shows that six of the seven events with the highest *impact on area-T1* responses were implementation events while four of seven events with the lowest *impact on area-T1* values were implementation events. This anecdotally suggests that, an implementation event (i.e., an event that includes may not be more likely to have an impact on the work area when compared to a non-implementation event. However, the next paragraph presents further evidence, particularly from the subset of events with the lowest *impact on area-T1* values, that appears to suggest that the degree of implementation achieved during the event may be a relevant factor.

Observations of the primary goals of the events with the highest and lowest *impact on area-T1* values provide additional insight into the regression findings. The primary goals of three of the seven teams with the highest *impact on area-T1* values were related to standardizing work and two of the seven events were related to implementing new layouts. The targeted activities of these five events appear to support *accepting changes*. For example, work area employees may be more likely to follow the new work methods if standard work documentation

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and visual cues are implemented. Also, a work area that is able to implement a new layout within the time frame of a Kaizen event (e.g., three to five days) may have greater tolerance and flexibility in terms of its ability to accommodate and accept changes.

Observation of the events with the lowest *impact on area-T1* values presents less apparent patterns across event goals. Two events related to addressing quality issues. One event was related to the development and implementation of a single line production layout. One event was related to the use of new equipment and yet another related to the determination of a line pace setter. However, further examination of these cases revealed that in all seven cases, the changes were not fully implemented for various reasons. Further examination of the categorization of how the goals, T0 performance, and T1 performance were reported by the respondents (see Section 3.3.1) revealed that the T0 performance was reported as "to be determined" at T0 in three of the seven cases. This indicates that the performance of the primary change related to the Kaizen event could not be fully determined at T0. These three cases were also non-implementation events. For example, event 319 was a non-implementation event that focused on the development of customer processes and product standards. The implementation of the new processes and standards was planned to occur after the Kaizen event but was never fully implemented due to a "shift in priorities" for the organization. Therefore, it is understandable that there was a lower perception of the impact on the work area.

In three out of seven cases, the change was defined and scheduled for future implementation or partially implemented at T0, but the change was never fully implemented. In the remaining case, event 615, the change was implemented but not maintained. The goal of event 615 was to change the pace setter of a line from one piece of equipment to another piece of equipment. During the event, a new piece of equipment was specified and adopted as the new line pace setter. However, since the event, the line pace setter was changed back to the original piece of equipment. In this example, the change as a result of the Kaizen event was essentially reversed. Although comments from the respondent suggest that the reversal of the change appears to have been beneficial to the work area, the fact that the change was reversed does assist in explaining why there were lower levels of impact on the work area from the Kaizen event.

From observing the goals of the events with the highest and lowest *impact on area-T1* values, a recommendation for management may be that in order to increase the perceived lasting impact that the Kaizen event has on the work area, it may be beneficial to plan and conduct

events that achieve the full implementation of change during the event, as this may make the solutions less susceptible to deterioration. When conducting non-implementation events or implementation events where the changes are only partially implemented, it may be beneficial to place additional emphasis on *accepting changes*. In cases where the original primary goal cannot be maintained for legitimate reasons (e.g., another solution is deemed to be more appropriate over time as was illustrated by event 615), it may be helpful to emphasize other changes that resulted from the Kaizen event (e.g., secondary safety or quality improvements) in order to increase perceptions of its impact on the work area.

Table 63. Events with the Highest and Lowest Impact on Area-T1 Values

Org	Event	Primary Goals of the Event	Impact on Area-T1	Acc. Changes
Events with Highest Impact on Area-T1 Values				
A	514	Standardize the equipment lubrication process, including establishing and posting standards	6.00	6.00
A	517	Design new layout of a designated work area to accommodate incoming equipment	6.00	6.00
A	523	Implement new layout of a designated work area to accommodate incoming equipment	6.00	5.50
A	530	Implement new layout of a designated work area to accommodate incoming equipment	6.00	6.00
A	532	Document and establish routine inspection and specifications of a specific piece of equipment.	6.00	5.00
A	550	7 Principles of Warehousing: Updating the inventory to reflect the current production mix	6.00	6.00
R	1907	Improve parts receivable as a smooth continuous flow enhanced by visual aides with a minimum of handling and a consistent standard process in a timely manner with adequate staffing	6.00	5.25
Events with Lowest Impact on Area-T1 Values				
Org	Event	Primary Goals of the Event	Impact on Area-T1	Accepting Changes
A	520	Create future state layout for work area to reduce handling damage and address ergonomic issues	3.00	5.00
C	615	Determine line pace setter through JIT	3.00	2.25
Q	1700	Decrease waste in work area by reducing lead time variability, throughput, operator travel, etc.	3.00	4.25
C	634	Implement a single piece of equipment (currently to separate pieces of equipment are needed)	2.33	4.00
B	319	Develop a customer inquiry to quote process and develop standards for a set of product lines. Consider policy deployment.	2.00	2.50
G	1802	Design and eventual implementation of a new, single line production line that reduces the cycle time of the work area (line)	2.00	2.00
E	114	Streamline process and reduce errors and omissions.	1.00	1.00

5.2.3 Comparison of Impact on Area-T1 to Impact on Area (Phase One of OSU-VT Research)

Finally, this section compares the critical factors of *impact on area-T1* to the critical factors of *impact on area* from the first phase of the OSU-VT research. In the first phase, *impact on area* as a result of a Kaizen event was positively related to *team autonomy*, *management support* and *action orientation* (focus on "hands-on" activities) (Farris, 2006). The strongest similarity between the phase one findings and the present research is between *management support* and the management-related component of *accepting changes*. This similarity was also present in the model of *work area attitude and commitment* and suggests that the role of management to support improvement efforts can influence the perceived impact on the work area during the Kaizen event (e.g., providing resources) and after the Kaizen event (e.g., accepting changes and holding employees accountable for following changes).

A difference between the *impact on area-T1* and *impact on area* models is that while *team autonomy* was a direct predictor of *impact on area* at T0, it is not a direct predictor of *impact on area-T1*. In other words, the team's freedom to make changes does not directly influence the perception of the impact of the Kaizen event over time. Instead, *accepting changes* positively influences *impact on area-T1*. Although these two variables are not directly related, they both allude to the importance of having a workforce that can freely and explicitly choose new work area changes which has been found to influence the institutionalization of change (Cummings and Worley, 1997). While *team autonomy* more directly relates to the freedom to select necessary changes during the Kaizen event, *accepting changes* implies that the work area employees have freely chosen to accept and follow the change as a result of the Kaizen event. Although *accepting changes* does not explicitly state that work area employees freely accepted the changes, a certain level of freedom and self-selection is assumed, i.e., this argument assumes that the work area employees were not forced to accept the changes by management. This similarity suggests that having a workforce that can freely choose work area changes may influence the perceived impact on the work area during the Kaizen event (e.g., team members making changes) and after the Kaizen event (e.g., work area employees accepting and following changes).

Action orientation was important to the immediate increased perceptions of *impact on area* (T0), but was not a direct predictor of *impact on area-T1*. However, it has been suggested

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that "increased levels of *action orientation* denote increased focus on implementation – i.e., making changes to the target work area" (Farris, 2006, p. 156).   Through the qualitative assessment of the events with the highest and lowest *impact on area-T1* values, a potential relationship between the the level of implementation that occurs during events and *impact on area-T1* was identified and should be explored further. Furthermore, the lack of immediate short-term returns on an improvement effort has been hypothesized by Keating et al. (1999) to result in lower employee buy-in to the programs and eventual failure to sustain the results of the improvement effort. In light of this hypothesis, the present research also suggests that there may be a relationship between the extent to which immediate changes occur during the event and the acceptance of change, which in turn may influence the perceptions of the lasting impact of the Kaizen event. In summary, it appears as though the action orientation or implementation focus of a Kaizen event may influence both the immediate and long-term perceptions of the impact of a Kaizen event on a work area.   While additional research is needed to fully understand this potential relationship, in the interim, management may wish to consider this potential influence.

5.3 Predictors of Result Sustainability

The average for the continuous measure of *result sustainability* was 85.26%, which suggests that a majority of Kaizen events were able to sustain a moderate level of their T0 performance at T1. Further, based on the dichotomous measure of *result sustainability*, approximately half (49.2%) of the Kaizen events studied were able to sustain or exceed their T0 performance at T1.   This finding is similar to earlier practitioner reports which suggest that organizations face difficulty in sustaining 50% of the improvements initially realized at the conclusion of the event (e.g., Laraia et al., 1999).

This research found that the most significant predictors of *result sustainability* (dichotomous variable) were *experimentation and continuous improvement* (direct negative), *performance review* (direct negative), *learning and stewardship* (direct positive), and *event planning process* (direct negative).   The direct predictors of *result sustainability* (binary measure) explained approximately 27% of the outcome variance (Figure 13). Thus, there is a great amount of additional variance that is not explained by the current model. This should be taken into consideration in interpreting these findings; i.e., additional variables or contextual

factors may be important in explaining the variation of *result sustainability*. However, the following sections further explain the model and how the findings may be interpreted.
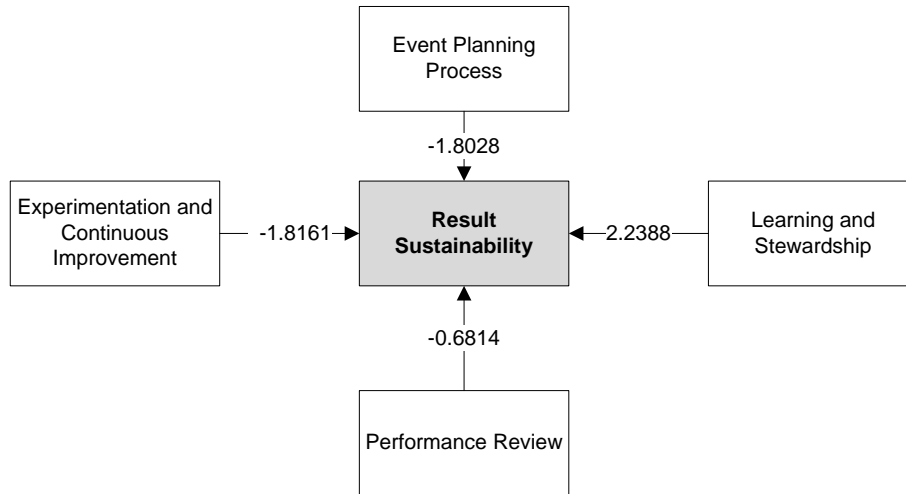
Figure 13. Result Sustainability Logistic Regression Model

5.3.1 Special Considerations Regarding the Result Sustainability Model
Upon initial observation of the *result sustainability* model, some features of the model do not appear to have face validity. Specifically, finding that *experimentation and continuous improvement*, *performance review*, and *event planning process* negatively influence whether or not results of a Kaizen event are sustained appears to be counterintuitive to the literature and common practice. For example, researchers note that *performance review* activities may prevent the deterioration of process-related improvements over time (Bateman and Rich, 2003; Kaye and Anderson, 1999; Dale et al., 1997). But contrary to previous research, the present model of *result sustainability* indicates that increased use of *performance review* activities may negatively influence *result sustainability*. However, further exploration of the present research's measurement of *result sustainability* provides additional insight into the model to assist in explaining these concerns.

Result sustainability* was ultimately operationalized as a binary objective measure of whether the reported results at T0 were still in place at T1. In other words, if the reported T0 performance was still maintained in the work area at T1, then result sustainability = 1, if not,

result sustainability=0. The time lapse between T0 and T1 and the fact that the time lapse varied across the sample (i.e., T1 data were collected approximately nine to eighteen months after the Kaizen event) may help to explain the fact that the model explains only 27% of the variation. Because this limitation may influence the other outcomes as well, it is more fully discussed as a part of the Research Limitations (Section 5.5). In addition to this limitation, the measure of *result sustainability* may produce unexpected results because of two additional reasons, discussed further in the following paragraphs: 1) the accuracy with which respondents are able to report their T0 and T1 performance and 2) the precision with which respondents are able to report their T0 and T1 performance. These concerns likely influenced the modeling of *goal sustainability* as well.

First, the accuracy with which respondents are able to report their T0 and T1 performance may impact *result sustainability*. Bateman and David (2002) note that the initially reported results of an improvement event (i.e., T0 performance) may have limited accuracy because of various practical working realities of the normal operation of the work area (e.g., employees working at a sustainable pace and having a range of skill levels among employees). The accuracy of the estimated T0 performance may also be influenced by the limited amount of time during the Kaizen event to make such assessments. In Bateman and David's (2002) assessment of whether or not work areas were able to sustain their results, adjustments were made based on these considerations. The present research did consider the extent to which the results at the end of the Kaizen event were accurate by testing the post-hoc variable *results accurate* as a potential predictor in the regression model. However, additional information regarding the extent to which reported results were greater than or less than the estimated results was not gathered. Therefore, it was not possible to adjust the T0 estimated results to account for normal operations, etc. and is a limitation to the measurement of *result sustainability*.

Secondly, the precision with which respondents are able to report their T0 and T1 performance may impact the measurement of *result sustainability*. The descriptive responses of the type of goals, T0 performance, and T1 performance were noticeably varied such that a categorization rubric was developed to ensure that comparable cases were measured similarly (see Section 3.3.1). However, the lack of precision of goals, T0 performance, and T1 performance from some respondents appeared to create an unexpected advantage when measuring *result sustainability* compared to respondents that provided additional precision or

detail regarding goals and performance. For example, one of the primary goals of event 1800 was to reduce the flow time between several related processes. The respondent's T0 performance was reported only as "achieved" and the T1 performance was reported as "same." In such cases, the researchers did attempt to glean additional information from the respondents. However, the respondents were not always able to provide additional information for various reasons (e.g., busy work environment or lack of having access to more precise measurements to report). Therefore, in this example, *result sustainability* =1. On the other hand, one of the primary goals of event 510 was to reduce the size changeover time in the work area from 50 seconds to 37.5 seconds (25% reduction). The respondent's T0 performance was "38 seconds" and the T1 performance was "39 seconds." Because the reported performance values are very specific, it is possible to calculate the exact percentage of results that were sustained and thus the binary measure of *result sustainability* = 0. While it could have been subjectively determined that this case should have a *result sustainability* value of "1," to make such subjective determinations throughout such a varied dataset would have been difficult and could have introduced unwanted bias in the measurement. In fact, only 23 of the 65 studied Kaizen events had objective, measureable results at T0 and T1. Therefore, it was not possible to adjust the T0 or T1 reported performance to account for measurement precision. Ideally, if all events studied had objective, measureable results at T0 and T1, this limitation would not be present. This limitation is likely related to the negative relationship that was found between *performance review* and *result sustainability* and the negative relationship between *event planning process* and *result sustainability,* which will both be further discussed.

5.3.2 *Literature Support of the Result Sustainability Model*

The following interpretation is influenced by the aforementioned concerns presented in Section 5.3.1. Collectively, these concerns seem to suggest that understanding the factors that may influence the long-term technical system benefits of a "successful" Kaizen event may not be solely related to whether or not the T0 performance was maintained. Instead, understanding these factors may also be related to having accurate and precise measures of T1 performance. Again, this possibility is supported by the fact that the dataset only included 23 of the 65 studied Kaizen events had objective, measureable results at T0 and T1. However, the following interpretation is only a postulation and additional research would be required to further explore the model of

result sustainability and these propositions. Findings from the post-hoc analysis alternative model of result sustainability using the subset of events (n=23) with objective, measureable performance at T0 and T1 (see Section 4.7) is used to further understand the research finding and are referred to as the "*result sustainability*-alternative model" findings. Specifically, the direction of the correlation (i.e., positive or negative) between *result sustainability* and each predictor from the *result sustainability*-alternative model is used to better understand the directional relationships found in the regression model. Therefore, the comparisons focus on the direction, rather than the strength (i.e., significance) of each correlation.

First, *learning and stewardship* was the only predictor found to be positively related to *result sustainability*; all of the other significant predictors were negative. The *result sustainability*-alternative model analysis found that the relationship between *learning and stewardship* was also positive (Kendall's tau=0.242, p=0.239; Spearman's rho=0.277, p=0.250), providing further insight into the direction of the relationship while providing some consideration for the possible influence of having accurate and precise T0 and T1 performance. This finding suggests that work area employees that practice group learning behaviors and feel responsible and accountable for the work area may be more likely to maintain the results of the Kaizen event. Work area employees with decreased levels of *learning and stewardship* may be less likely to maintain the result of the Kaizen event. It should be noted that *learning and stewardship* was also an indirect predictor of the other technical system outcomes, *impact on area-T1* and *overall success*, and these outcome variables were significantly correlated.

Experimentation and continuous improvement was found to be negatively related to *result sustainability*. Additional exploration of the relationship between *learning and stewardship* and *experimentation and continuous improvement* revealed that the variables were highly correlated (0.686, p < 0.0001), which may account for the negative relationship, i.e., there may be a "trade-off" between the variable that is dominant in the model. However, the *result sustainability*-alternative model analysis found that the relationship between *experimentation and continuous improvement* was also negative (Kendall's tau=-0.213, p=0.309; Spearman's rho=-0.240, p=0.323), providing further insight into the direction of the relationship.

Alternative explanations of the relationship between *experimentation and continuous improvement* and *result sustainability* were explored. For example, if work area employees exhibit increased *experimentation and continuous improvement*, they may tend to continually

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improve upon a solution or experiment with alternative solutions in the work area. Therefore, it appears to be reasonable that higher perceptions of *experimentation and continuous improvement* may make it less likely to maintain T0 performance at T1 (*result sustainability* = 0). On the other hand, lower perceptions of *experimentation and continuous improvement* may mean that the work area employees are less likely to try new ideas, which may make it more likely that the work area would maintain the T0 performance at T1 (*result sustainability*=1). Another alternative explanation relates to the role of the workforce's knowledge of continuous improvement. A workforce that is very aware of the importance of the importance of continuous improvement and very knowledgeable about continuous improvement may be more critical of the level of performance sustainability in the work area and may tend critique their levels of *result sustainability* to a greater extent. This may lead to lower reported *result sustainability* values (and a binary measure of *result sustainability* = 0).

Event planning process was found to be negatively related to *result sustainability*. The correlation between *result sustainability* and *event planning process* in using the subset of Kaizen events that had objective, measureable results at T0 and T1 (n=23) was also negative (Kendall's tau=-0.228, p=0.033; Spearman's rho=-0.271, p=0.0.031), providing further insight into the direction of the relationship. This finding appears to suggest that work areas that place emphasis on detecting opportunities for additional improvement may be less likely to sustain results from previous improvements. For example, if extensive time and human resources are used to plan Kaizen events, then it is possible that the resources and supporting activities needed to sustain results are not available or emphasized in the work area. This alternative is not suggesting that *event planning process* activities are not appropriate; instead it suggests that there may be an efficient level of practice for these activities which may involve fewer hours of event planning; furthermore, if the efficient level of *event planning process* is exceeded, *result sustainability* may begin to deteriorate. Additional research involving data envelopment analysis that explores the relative productive efficiency of a set of comparable organizational units based on a theoretical optimal performance for each organization (Charnes et al., 1978; Cooper et al., 2006) would be helpful to explore this possibility.

Finally, *performance review* was found to be negatively related to *result sustainability*. However, the *result sustainability*-alternative model analysis found that the relationship between *performance review* was positive (Kendall's tau=0.563, p=0.014; Spearman's rho=-0.582,

p=0.009). Furthermore, the alternative model (n=23) of *goal sustainability* found that *performance review* was positively related to the outcome. These findings suggest that the actual effect of *performance review* on *result sustainability* may be positive, particularly after accounting for the accuracy and precision of T0 and T1 performance. For example, if a work area conducts *performance review* activities, it may be more likely to have more accurate and precise measures of T0 performance and T1 performance. *Performance review* activities may also make it possible to detect when the results reported at T0 are not fully sustained at T1. On the other hand, if accurate and precise T0 and T1 performance have not been identified, potentially due to a lack of performance measures in the work area, then *performance review* may have limited application in the work area which may also produce inaccurately reported T1 performance that may unintentionally influence a *result sustainability* value of 1.

Alternatively, if the negative direction of the regression model is interpreted, then higher levels of *performance review* may suggest that work areas that place additional emphasis on performance review meetings may be less likely to sustain results from previous improvements. For example, if extensive time and human resources are used in *performance review* activities (e.g., meetings with higher level management), then it is possible that the time needed to actually guide the work area employees to sustain the improvements. Similar to *event planning process*, this alternative would suggest that additional research may be needed to determine if there may be an efficient level *performance review* activities.

It should be noted that *production system changes* (β= 2.458, p=0.043) was the only significant variable in the model of *result sustainability*-alternative model (Negelkerke R^2 = 0.424). The finding may suggest that a greater amount of changes in a work area may increase the likelihood that results are sustained and in Kaizen events that have objectively measured T0 and T1 outcomes, *production system changes* may be a significant predictor of success. *Production system changes* was also included in the model of *work area attitude and commitment* which suggests that further research to explore the influence of *production system changes* on the work area is needed.

5.3.3 Observation of Events with Highest and Lowest Result Sustainability Values

In order to provide further explanation of the research results, additional observation of the events with the highest and lowest values for the continuous measure of *result sustainability*,

including a comparison of their reported values of *learning and stewardship, experimentation and continuous improvement*, *performance review*, and *event planning process* was conducted (Table 64). A caveat to these observations is that because the model is based on the binary measure of *result sustainability*, it is less precise than the continuous measure of *result sustainability*. Therefore, there may be additional factors that were found to be significant in the binary model of *result sustainability* that may not be significant when observing the continuous measure of *result sustainability*. Events with the five highest responses for *result sustainability* occurred in Organizations A (one event), E (two events) and G (two events). Their *result sustainability* values were all higher than 100%, meaning that these teams were able to exceed the results that were reported at the end of the Kaizen event studied. Unlike the previously-discussed outcomes, the predictor values were not consistently higher across the events with the five highest responses for *result sustainability*. In fact, there appeared to be greater variation of predictor values across the subset of events with the highest responses of *result sustainability* compared to the predictors of the highest values of the other outcome variables. This greater variation may provide an explanation for the low predictive capabilities of the *result sustainability* model compared to the modeling of the other outcomes. For this subset of events, the values for the predictor *learning and stewardship* ranged from 3.29 to 5.86 (average 4.89), *performance review* ranged from 1.2 to 5.6 (average 3.0), *experimentation and continuous improvement* ranged from 3.25 to 5.5 (average 4.45), and *event planning process* ranged from 5 to 20 hours (average 11.67 hours).

Events with the five lowest responses for *result sustainability* occurred across five different organizations. The events with the lowest continuous *result sustainability* values all equaled 0% meaning that none of the primary results that were reported at the end of the studied Kaizen event were sustained. For this subset of events, the values for the predictor *learning and stewardship* ranged from 2.29 to 5.0 (average 3.60), *performance review* ranged from 1.6 to 4.4 (average 2.96), *experimentation and continuous improvement* ranged from 2.5 to 5.0 (average 3.75), and *event planning process* values ranged from 2 to 40 hours (average 15.8 hours).

Comparison of the events with the highest and lowest *result sustainability* values reveals a few notable findings. First, two of the five events with the lowest responses for *result sustainability* were implementation events while three of the five events with the highest *result sustainability* values were implementation events. This anecdotally suggests that the

implementation focus of an event may not provide substantial explanation regarding the prediction of *result sustainability*. In other words, an implementation event may not be more likely to sustain results when compared to a non-implementation event. Secondly, *learning and stewardship* did have higher values for the subset with the highest *result sustainability* values compared to the subset with the lowest *result sustainability* values which is in support of the regression findings that found *learning and stewardship* to be a positive predictor of *result sustainability*.

The average of *performance review* and *event planning process* had either lower or similar values for the subset with the highest *result sustainability* values compared to the subset with the lowest *result sustainability* values. This observation does not provide clear support of the regression findings that found these predictors to be negatively related to *result sustainability*. *Experimentation and continuous improvement* had higher values for the subset with the highest *result sustainability* values compared to the subset with the lowest *result sustainability* values. These findings contradict the regression findings that found *experimentation and continuous improvement* to be a negative predictor of *result sustainability*. Overall, the observations his suggest that while *experimentation and continuous improvement, performance review* and *event planning process* are a negative predictors of the binary measure of *result sustainability*, there is not a clear pattern with respect to the continuous measure of *result sustainability*.

Observation of the primary goals of the events with the highest and lowest *result sustainability* values also provide additional insight into the regression findings. The primary goals of three of the teams with the highest *result sustainability* values were related to standardizing work which may support lasting improvement (Martin, 2007). Two events were related to improving quality (creating guidelines and processes to improve quality). In terms of how the goals were categorized (according to Section 3.3.1), there did not appear to be a discernable pattern.

Observation of the events with the lowest *result sustainability* values were similar to the observation of the events with the lowest *impact on area-T1* values and three of the five events were also observed to have the lowest values of *impact on area-T1*. This observation relates to the fact that *impact on area-T1* and *result sustainability* were found to be significantly correlated ($r = 0.578$, $p < 0.0001$). One event was related to addressing quality issues. Two events related

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to the development and eventual implementation of a production layout. An additional event related to the implementation of a new piece of equipment. Further examination of these cases revealed that in all five cases, the changes were not fully implemented for various reasons. Further examination of the categorization of how the goals, T0 performance, and T1 performance were reported by the respondents (see Section 3.3.1) revealed that the T0 performance was reported as "to be determined" in two of the five cases, indicating that the performance of the primary change related to the Kaizen event could not be fully determined at T0. These three cases were also non-implementation events. In the remaining three out of five cases, the change was determined or partially implemented at T1, but was never fully implemented. Expert practitioners note that partial implementation of outcomes may negatively influence the success and sustainability of events and that full implementation is preferred (Martin and Osterling, 2007). From observing the event goals of highest and lowest *result sustainability* values, a recommendation for management may be that in order to increase the likelihood of whether or not the T0 performance will be maintained, it may be beneficial to conduct events that implement the change during the event as this may make the change less susceptible to deterioration over time.

Table 64. Events with the Highest and Lowest Result Sustainability Values

Events with Highest Result Sustainability Values							
Org	Event	Primary Goals of the Event	Res. Sust.	Learn. and Stew.	Perf. Rev.	Exp. and CI	Event Plan.
G	1806	Improving tool set by purchasing additional tools, including, smaller tools for the work area	1.40	5.71	5.20	5.50	6
G	1807	Create guidelines for product installation process and improve supplier and internal quality	1.40	3.29	1.20	3.25	11
E	104	Streamline the quote request and quote management processes	1.32	4.71	1.80	3.75	20
A	550	7 Principles of Warehousing: Updating the inventory to reflect the current production mix	1.14	5.86	5.60	4.75	8
E	113	Streamline a process and ensure that the process is correct the first time to reduce processing time and scrap.	1.11	4.86	1.20	5.00	20
Events with Lowest Result Sustainability Values							

Org	Event	Primary Goals of the Event	Res. Sust.	Learn. and Stew.	Perf. Rev.	Exp. and CI	Event Plan.
E	114	Streamline process and reduce errors and omissions.	0.00	2.29	2.20	2.50	4
A	520	Create future state layout for work area to reduce handling damage and address ergonomic issues	0.00	5.00	3.40	5.00	2
C	634	Implement a single piece of equipment (currently to separate pieces of equipment are needed)	0.00	3.57	4.40	3.50	3
G	1802	Design and eventual implementation of a new, single line production line that reduces the cycle time of the work area (line)	0.00	3.29	3.20	4.00	40
R	1905	Standardizing the process to deliver components that are ready to install to the product in the defined quantities	0.00	3.86	1.60	3.75	30

5.3.4 Comparison of Result Sustainability to Goal Achievement (Phase One of OSU-VT Research)

Finally, this section compares the critical factors of *result sustainability* to the critical factors of *goal achievement* from the first phase of the OSU-VT research. The first phase found that *event planning process* (hours spent planning the event) was positively related to *goal achievement*, while *action orientation, goal difficulty, team kaizen experience* and *team leader experience* were all negatively related to *goal achievement* (Farris, 2006). This present research found that *learning and stewardship* was positively related to *result sustainability* and *experimentation and continuous improvement*, *performance review*, and *event planning process* were negatively related to *result sustainability*.

Interestingly, *event planning process* was positively related to *goal achievement* but negatively related to *result sustainability*. As explained in Section 3.3.1, the negative relationship between *event planning process* and *result sustainability* may be explained by the *result sustainability* measurement issues. However, the fact that the variable is significant in both models does imply that further research of the influence of *event planning process* on short-term and long-term achievement of Kaizen event results may be beneficial and that *event planning process* may have implications for managers and Kaizen event facilitators. For example, future research of *result sustainability* could account for the measurement limitations presented in Section 5.4.1 and could be able to explain a greater percentage of variation

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compared to the present model. In the *result sustainability*-alternative model*, event planning process* was found to be negatively correlated to *result sustainability,* which at least suggests that management should consider the amount of time that is spent planning for Kaizen events as the *event planning process* may influence the short-term and long-term achievement of Kaizen event results. However, definitive recommendations regarding the direction of the relationship between planning and long-term results cannot be made based on the current research findings and should be further explored.

Meanwhile, *action orientation* was found to negatively impact *goal achievement* (T0), suggesting that having a higher *action orientation* is not always preferable (e.g., a balance between planning and *action orientation* may be ideal). *Action orientation* was not a direct predictor of *result sustainability*. However, similar to the explanation presented regarding action orientation and *impact on area-T1*, a potential relationship between the extent to which changes occur during the Kaizen event and *result sustainability* should be explored further. Examination of both models and the role of *action orientation* may suggest that while having a higher *action orientation* may limit a team from achieving immediate goals, the implementation of the desired change during the event may in turn support the preservation of the change. On the other hand, *experimentation and continuous improvement*, an action-oriented learning behavior, was found to be a negative predictor of *result sustainability,* which may further suggest that action-oriented activities may lead to decreased levels of *result sustainability.* Again, while definitive recommendations cannot be made based on the current results, escpecially regarding the direction of the relationship between action-oriented activities and *result sustainability*, one may postulate that because the implementation focus may influence both models, further research of the role of *action orientation* may be beneficial to the advancement of knowledge regarding immediate and long term Kaizen event performance.

5.4 Predictors of Overall Success

Through post-hoc analysis, the research found that the most significant predictors of *overall success* were *accepting changes* (direct positive), *results accurate* (direct positive) and *learning and stewardship* (indirect positive). The direct predictors explained approximately 50% of the outcome variance (Figure 14).

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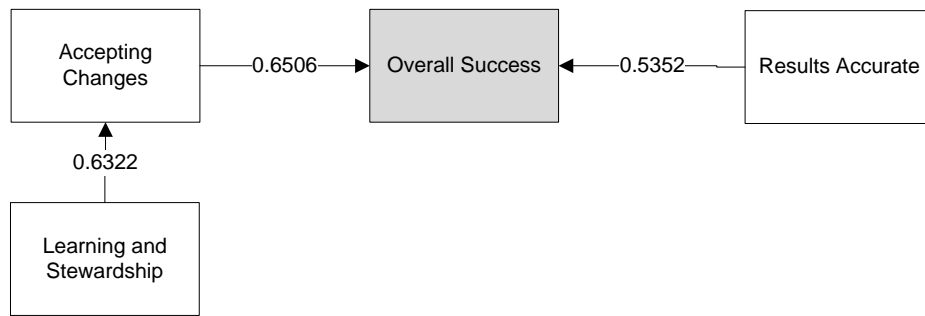
Figure 14. Overall Success Model

5.4.1 Literature Support of Overall Success Model

Overall success describes perceptions of the overall success of the Kaizen event approximately nine to eighteen months after the Kaizen event. The average *overall success* was 4.91 and suggests that there were moderate levels of overall success of the Kaizen event. The model appears to be very similar to the model for *impact on area-T1* in that they both include *accepting changes* as a direct predictor of the outcome variable and *learning and stewardship* is mediated by *accepting changes* in both models. The similarities between the *impact on area-T1* and *overall success* models appear to have face validity because both variables refer to perceptions of the general long-term effectiveness of the Kaizen event. *Impact on area-T1* and *overall success* were also found to be significantly correlated ($r = 0.563$, $p < 0.0001$). Also, the significance of *accepting changes* in both models appears to be supported by the fact that perceptions of *impact on area-T1* and *overall success* may relate to both objective, performance-related improvements as well as more subjective improvement, e.g., perceptions of an improvement work area culture or perceptions of the amount of buy-in from the workforce and management (Farris, 2006). Also, *learning and stewardship* was a mediated variable in both the *impact on area-T1* and *overall success* models and suggests that *accepting changes* activities may be present to a greater extent in work areas that encourage *learning and stewardship* among their employees.

The additional variable that was found to be positively related to *overall success* but was not significant in the *impact on area-T1* model, was *results accurate* ("Now, I believe the estimated results at the end of the Kaizen event were accurate") was found to be positively related to *overall success*. Thus, having initial results that are inaccurate appear to have an

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adverse effect on *overall success*. Previous Kaizen event research has noted that identifying accurate results may be difficult due to measurement challenges and time constraints (Bateman and David, 2002; Marin-Garcia et al., 2009). This finding implies that, despite the difficulties that may occur with determining accurate results at the end of the Kaizen event, additional effort to estimate results as accurately as possible may be warranted as accurate results it may increase the perception of long-term overall success.

The relationship between *results accurate* and *overall success* may also relate to the perception of benefits from an improvement project. Keating et al. (1999) suggest that the workforce and managers determine their perceptions of the effectiveness of an improvement effort by comparing the rate of progress they observe to their expectations. Commitment increases if progress is high relative to aspirations but tends to decrease when progress is disappointing relative to expectations. Therefore, stretch objectives can motivate greater effort by increasing people's aspirations as people "Rise to the Challenge," but create a "Credibility Gap" that undermines effort when objectives are set too high. In the "Credibility Gap," the workforce believes that the goal was infeasible, the employees may become frustrated and cynical, and the credibility of the goal and the credibility of management (provided management set the goal) may begin to erode over time (Keating et al., 1999).

Similar to the objectives discussed by Keating et al. (1999), the reported T0 performance serves as an objective for the work area employees to maintain or exceed. The measure, *results accurate*, does not measure whether or not the perceived inaccuracy present in T0 performance caused the T0 performance to be higher or lower than the actual results. However, it appears as though estimating results that are too ambitious may be more common than estimating results that are too conservative (Bateman and David, 2002). Therefore, if the T0 reported results are inaccurate in terms of being too ambitious, the expectations for improvement may be very high. When these expectations are not met, the perception of progress or success of the improvement may decrease. One difference between Keating et al.'s (1999) observations and the present research is that the former focuses on "stretch" objectives set by management. In the present research, the reported results at T0 may be at least partially determined by the Kaizen event team. Therefore, perceptions of lessened "credibility" may not be directed at management in these cases, but at the Kaizen event process Practically, this explanation suggests that greater perceptions of overall improvement may be attained by reporting more accurate, possibly more

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conservative, results at the end of the Kaizen event. If the T0 performance is found to be inaccurate, it may be beneficial to communicate this inaccuracy to the workforce, Kaizen event facilitators, etc. in order to adjust the expectations for the improvement effort.

Alternatively, the relationship between *results accurate* and *overall success* may also imply that, now, the respondents do not believe that the results were accurate because the long-term success of the event was low, i.e., it was not possible to sustain the improvements. This proposition is based on the possibility of reverse causality. In other words, the overall success of the event may influence the T1 perception of the accuracy of the initial results. The correlation found between *overall success* and *result sustainability* provides some support for this alternative ($r = 0.337$, $p < 0.006$). However, the possibility of reverse causation is reported in longitudinal studies (e.g., Zapf et al., 1996). Furthermore, causality concerns and the potential for bias in the use of retrospective pretests, i.e., where the data collected at T1 refers to T0 activities, has also been reported (Hill and Betz, 2005). This alternative interpretation supports the idea that researchers should be aware of the potential influence of reverse causation when studying the influence of a phenomenon over time.

5.4.2 Observation of Events with Lowest Overall Success Values
In order to provide further explanation of the research results, additional observation of the events having the highest and lowest values for each outcome variable was conducted. Twenty events had a response of '6' for *overall success*, suggesting that that the Kaizen event made a high impact on the targeted work area. For this subset of events, *accepting changes* ranged from 4.0 to 6.0 (average 5.5) and *results accurate* ranged from 3.0 to 6.0 (average 5.35) With such a large number of events with the highest possible value of *overall success*, one might expect more skewness in the data, but the dataset had several lower reported values for *overall success* as well, preserving the relative normality of the dataset. However, because there was a larger number of events with the highest *overall success,* the following observations focus on the events with the lowest *overall success* values (Table 65).

Events with the lowest responses for *overall success* occurred in five of the eight organizations. Their *overall success* values for the subset of events with the lowest responses for *overall success* were all less than 3.0 (average 2.25), suggesting that there were lower levels of overall success of the Kaizen event. The average value of *accepting changes* was noticeably lower across this subset of events and there was clearly greater variation as *accepting changes*

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ranged from 1.0 to 5.0 (average 3.56). Also, *results accurate* had a lower mean (average 3.50) and was more variable across this subset of events (ranged from 1.0 to 6.0).

Observation of the primary goals of the events with the lowest *overall success* values also provide additional insight into the regression findings and are very similar to the *impact on area-T1* observations. In fact, five of the eight events with the lowest *overall success* values also had the lowest *impact on area-T1*. Initial observation of the events with the lowest *overall success* values presents less apparent patterns across event goals. Two events related to addressing quality issues. One event was related to the development and implementation of a single line production layout. One event was related to the use of new equipment and yet another related to the determination of a line pace setter. Also, five of the eight events with the lowest *overall success* values were categorized as implementation-oriented events. However, further examination of these cases revealed that in all eight cases, the changes were not fully implemented after the event for various reasons. Further examination of the categorization of how the goals, T0 performance, and T1 performance were reported by the respondents (see Section 3.3.1) revealed that the T0 performance was reported as "to be determined" at the end of the event in three of the eight cases indicating that the performance of the primary change related to the Kaizen event could not be fully determined at T0. For example, the goal of non-implementation event 114 was to streamline the process and reduce errors and omissions. The results at the end of the Kaizen event, i.e., T0 performance, were reported as "TBD" and T1 performance was reported as 0% because of a lack of support as well as a lack of time, money, and other resources. The *accepting changes* response for event 114 was 'strongly disagree' which further supports the qualitative elaboration from the respondent that, in this event, it does not appear as though management accepted or reinforced the targeted change. The perception of the *overall success* of this Kaizen event was 'strongly disagree'. Collectively, this example appears to provide some subjective support for the significance of *accepting changes* in the model of *overall success*.

In the remaining five out of eight cases, the change was determined or partially implemented at T1, but was never fully implemented or the expected changes were not fully realized. For example, event 504 was an implementation event to improve the material flow of small lot sizes to the cells by implementing several changes (e.g., using new storage carts). Several physical improvements were made to the work area during the Kaizen event. However,

the estimated results (increase in productivity and throughput) were never realized. This example appears to relate to the direct predictor, *results accurate*. The estimated results at T0 were very ambitious, so even though the respondent had moderate levels of agreement regarding the accuracy of the results, the fact that the estimated results were not achieved may why the respondent had lower levels of agreement regarding the *overall success* of the Kaizen event.

From observing the event goals of highest and lowest *overall success* values, a recommendation for management may be that in order to increase perceived impact that the Kaizen event has on the work area over time, the change as a result of the Kaizen event should be implemented and followed. It may be beneficial to conduct events that are more implementation oriented with more accurately reported T0 results as it may make the solutions less susceptible to deterioration. When conducting non-implementation events, it may be beneficial to place additional emphasis on *accepting changes*.

Table 65. Events with the Highest and Lowest Overall Success Values

Events with Lowest Overall Success Values					
Org	Event	Event Goal	Overall Success	Accepting Changes	Results Accurate
A	504	Improve material flow of small lot sizes to the cells by implementing several changes (e.g., using new storage carts)	3.0	5.00	4.0
A	520	Create future state layout for work area to reduce handling damage and address ergonomic issues	3.0	5.00	5.0
C	615	Determine line pace setter through JIT	3.0	2.25	3.0
Q	1700	Decrease waste in work area by reducing lead time variability, throughput, operator travel, etc.	3.0	4.25	3.0
E	113	Streamline a process and ensure that the process is correct the first time to reduce processing time and scrap.	2.0	3.50	3.0
B	319	Develop a customer inquiry to quote process and develop standards for a set of product lines. Consider policy deployment.	2.0	2.50	3.0
E	114	Streamline process and reduce errors and omissions.	1.0	1.00	6.0
E	115	Design a cell for project orders, to improve quality, efficiency, and safety	1.0	5.00	1.0

5.4.3 Comparison of Overall Success to Overall Perceived Success (Phase One of OSU-VT Research)

Finally, this section compares the critical factors of *overall success* to the critical factors of *overall perceived success* from phase one of the OSU-VT research. In phase one, *overall perceived success* as a result of a Kaizen event was positively related to *tool quality* but the model R^2 was relatively low due to low variation in the *overall perceived success* measure and the fact that *overall perceived success* was a single item measure (Farris, 2006). In the present research, the variation of *overall success* was much greater than *overall perceived success,* which may possibly help to explain why the model of *overall success* was able to explain more variation than the phase one model of *overall perceived success*.

5.5 Research Limitations

Section 1.5 discussed several limitations to the research related to the research design and collection methods in detail, including:

- This research did not attempt to study all potential Sustainability Outcomes.
- This research's sample size was limited in terms of the number, type, and location of participating organizations which may impact generalizability.
- Survey data regarding the perceptions of the workforce (e.g., perceptual Work Area Characteristics) were collected from facilitators or work area manager as opposed to collecting the data from the workforce.
- Because of the exploratory nature of the research, particularly the regression analysis, it is possible that the independent variables that most appropriately model the Sustainability outcomes were not selected.
- Across the organizations studied, there was a variable time lapse between the collection of T0 and T1 data (i.e., approximately nine to eighteen months after the Kaizen event).

This section specifically elaborates on the limitations that were found or reinforced through the analysis and interpretation of results.

First, this research did not attempt to study all Kaizen Event Characteristics, Work Area Characteristics, or Post-Event Characteristics that may impact Kaizen event outcome sustainability. Instead, Kaizen event sustainability literature and related literature were used to determine the characteristics that have been identified by previous studies as the factors most

likely to be critical to the sustainability of Kaizen event outcomes. While there was theoretical support for the inclusion of the variables studied, approximately 50% of the variance in *work area attitude and commitment, impact on area-T1*, and *overall success* was not accounted for in their respective models. Additionally, the model of *result sustainability* only explained 27% of the variance. This suggests that the consideration of additional variables may assist in explaining a greater amount of variance for each outcome. Additional variables that could be considered for future research are suggested in Chapter 6.

Several issues related to the maturity of measurement in the targeted work area, including the accuracy and precision of the results, may influence the study of certain Sustainability Outcomes, particularly *result sustainability* and *goal sustainability*. These issues in part illustrate the lack of experimental control in the research. While future research could consider an experiment or quasi-experiment to control for some of these factors, these methods present their own limitations in terms of studying a real world phenomenon. Alternatively, action research may be a beneficial research approach for future research as researchers would then have more control over when and how T0 and T1 performance were reported. But as with any form of research, action research also has its limitations, e.g., resources and access to organizations to conduct action research may be difficult. However, based on the research findings, future research approaches and designs are considered in Chapter 6.

CHAPTER 6: CONCLUSIONS

This chapter presents the collective findings of this research, highlighting the variables that were significant across outcome variables. Also, this chapter describes areas of future research that were identified as a result of this study.

6.1 Summary of Research Findings

Table 66 presents a summary of the research findings, including the direct and indirect predictors of each outcome variable. Positive relationships are indicated with a '+' and negative relationships are denoted with a '-'. Indirect relationships are indicated and for the one variable that had a direct and indirect relationship, *experimentation and continuous improvement*, both the direct and indirect relationships are indicated.

Table 66. Summary of Relationships Identified in Research

	Work Area Attitude and Commitment	Impact on Area-T1	Result Sustainability	Overall Success
Work Area Routineness	**-** (indirect through PR)			
Event Planning Process			**-**	
Results Accurate				+
Learning and Stewardship	+ (indirect through PR)	+ (indirect through AC)	+	+ (indirect through AC)
Experimentation and Continuous Improvement	+ (direct and indirect through AC)		**-**	
Production System Changes	+ (indirect through AC)			
Performance Review (PR)	+		**-**	
Accepting Changes (AC)	+	+		+

Table 66 emphasizes the variables that were significant in a single model or across multiple models. The variables that were significant in a single model were *work area routineness*, *event planning process, production system changes*, and *results accurate*.

- *Work area routineness* was found to be a negative, indirect predictor of *work area attitude and commitment* through *performance review*, which implies that management may wish to consider the influence that the routineness of the work area may have on performance review activities (e.g., may be difficult to define metrics or conduct audits in a less routine work area) and consider ways to counteract this negative relationship (e.g., focus on other variables that positively influence *work area attitude and commitment* that may offset this potential disadvantage).

- *Production system changes* was positively, indirectly related to *work area attitude and commitment* through *accepting changes* which suggests that work areas that experience changes in product mix, etc., may be more likely to be accepting of other changes. This finding does not necessarily suggest that managers should encourage production system changes, especially if they are unwarranted; however, it does suggest that if a change related to the production-system is needed, then management need not be hesitant to make the change for fear of negatively influencing the workforce.In fact, as work area employees experience such production system changes, it may increase their acceptance of change and they may more easily adapt to other changes over time, such as changes resulting from a Kaizen event.

- *Event planning process* was negatively related to *result sustainability*. Because the *result sustainability* model explained a limited about of variability and appeared to be confounded by measurement issues, the full interpretation of this relationship is not clear. However, because *event planning process* was significant in both the model of goal achievement at T0 and *result sustainability* at T1, further research of *event planning process* may be beneficial and may have implications for managers and Kaizen event facilitators.

- *Results accurate* was positively related to *overall success,* which implies that Kaizen event teams and management should report accurateresults, e.g., avoid overestimating T0 performance, at the end of the Kaizen event. If the reported results at T0 are found to be inaccurate, it may be beneficial to communicate this inaccuracy to the workforce, Kaizen event facilitators, etc. in order to adjust the expectations of the improvement effort.

Learning and stewardship, experimentation and continuous improvement, accepting changes, and *performance review* were found to be significant across multiple models (Table 66). *Learning and stewardship* had a significant effect (direct or indirect) in all four models, *accepting changes* was significant in three models, and *performance review* and *experimentation and continuous improvement* were significant in two models. *Accepting changes* and *performance review* are Post-Event Characteristics. *Learning and stewardship* and *experimentation and continuous improvement* are Work Area Characteristics that relate to the group learning behaviors of the workforce. The variables that were significant across multiple models appear to provide support for two key concepts: the importance of having a learning organization and the importance of supporting the development of a continuous improvement culture. Furthermore, previous research that presents an apparent link between learning and a continuous improvement culture and their collective importance in sustaining improvements (e.g., Kaye and Anderson, 1999; Oxtoby et al., 2002) provides further support for the importance of these concepts. In practice, management can cultivate learning behaviors by encouraging shared peer learning activities, developing "good stewards" in the workforce, encouraging experimentation, and explaining the importance of continuous improvement. Moreover, management can further foster continuous improvement through the use of performance review activities and by supporting activities that ensure changes are accepted, followed, and reinforced.

Post-hoc analysis of the bivariate correlations of the Sustainability Outcomes found that there was at least marginal support for all relationships except *work area attitude and commitment* and *result sustainability*, which is clearly not significant. Practically, these findings suggest that management may wish to focus on the factors that influence *impact on area-T1* and *overall success* as they were the outcomes that related to all other outcomes and for which the hypothesis testing for the full sample was conclusive (*goal sustainability* was also correlated to all other outcomes, but further research is needed to determine its predictors). Additional research of result sustainability may provide additional insight for management regarding its relationship with positive attitudes toward Kaizen events over time and overall perception of success.

Finally, it is interesting to review the variables that were not found to be significant in the research model. Only one Kaizen Event Characteristics, *event planning process,* was found to be significant in the research findings, including the originally hypothesized Kaizen Event

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Characteristics and the post-hoc variables. This suggests that Kaizen Event Characteristics may play a greater role in the achievement of immediate outcomes than on Sustainability Outcomes. However, this does not mean that management should not consider Kaizen Event Characteristics. On the contrary, the Kaizen Event Characteristics that were significant to immediate outcomes at T0 may still be important to the Sustainability Outcomes because of influence that achieving immediate outcomes may have on Sustainability Outcomes. However, there are divergent research findings regarding the influence of immediate outcomes on improvement sustainability. For example, it has been found that positive attitudes at the conclusion of a successful event do not automatically translate to sustained performance improvement or employee enthusiasm (Doolen et al., 2008). On the other hand, achievement of immediate benefits has been found to create employee buy-in (e.g., commitment) to an improvement program over the longer-term which may influence sustained performance (Keating et al., 1999; Kotter, 1995). Additional research regarding the relationships between immediate outcomes and outcomes over time would provide further insight into these divergent findings.

The only objective Work Area Characteristic that was found to be significant in the research findings was *production system changes*. The other variables, *management Kaizen event participation at T0, management Kaizen event participation at T1, management change,* and *employee change* were not significant. The variables *management Kaizen event participation at T0* (occurred in one of the 65 observations) and *management Kaizen event participation at T1* (occurred in eight of the 65 observations) may still be relevant to the study of Kaizen event sustainability, but they were not statistically significant in the current dataset.

While more variability was observed in *employee change,* most of the current employees had also been in the work area during the Kaizen event (*employee change* = 77.40%; i.e., 77.4% of the current work area employees were in the work area at the time of the Kaizen event). Previous research suggests that employee turnover may indicate a loss of knowledge in the work area which may negatively influence improvement sustainability (e.g., Dale et al., 1997; Keating et al., 1999). Other research did not find a significant relationship between turnover and Kaizen event sustainability outcomes (Burch, 2008), but like the present research, the sample had a low turnover rate (two of the thirteen organizations studied reported high turnover). Thus, it is possible that a low employee turnover rate may support the sustainability of Kaizen event

outcomes but was not significant because of the lack of variation within the sample and warrants further research.

The binary variable *Management change* was reported with a somewhat similar frequency between the "yes" responses (27) and the "no" responses (37). The fact that it was not significant in the model may be explained by possibilities that were not directly explored in this research. For example, while a change in management may have occurred, it may be the case that the new management was already an employee of the organization, possibly even a member of the work area. Furthermore, the absence of *management change* in the model may suggest that the organizations studied were able to maintain a consistent managerial approach even if the new management came from outside the organization.

Also, *institutionalizing change* and *improvement culture* were also not found to be significant predictors of Sustainability Outcomes. However, *improvement culture* was found to be significant in some of the exploratory modeling of the continuous measure of result sustainability and in the post-hoc modeling of result sustainability for implementation events with objectively reported T0 and T1 performance (Section 4.1.7). The survey scale items of *institutionalizing change* represent a variety of follow-up activities that may occur after a Kaizen event in order to complete action items, etc. (e.g., IChange1: "Formal documentation of follow-up action items (e.g., through a Kaizen newspaper) from the Kaizen event" and IChange5: "Involving work area employees (not on the Kaizen event team) in follow-up and completion of action items from the event"). It is possible that the *institutionalizing change* was not a significant predictor of Kaizen event outcomes because it is somewhat similar to *accepting change*. *Institutionalizing change* focuses more on the extent to which specific mechanisms are followed while *accepting change* focuses on the overall approach of accountability to follow new procedures and mechanisms. However, while the *institutionalizing change* was not significant in the present research, the importance of *institutionalizing change* activities has been cited frequently enough in the Kaizen event sustainability literature (e.g., Bateman, 2005; Burch, 2008) and practitioner resources to warrant future research. It may be possible that alternative ways of measuring follow-up activities for qualitative research may be necessary. Furthermore, *institutionalizing change* was a new variable to this research, i.e., it was not adapted from an existing survey scale but rather from follow-up activities related to completing action items that

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were frequently cited. Confirmatory factor analysis using a larger sample size could be used to confirm the validity of the construct.

6.2 Future Research: Testing of Additional Variables

Interestingly, while 16 variables were originally hypothesized to influence the outcome variables and additional post-hoc variables were tested, in total, there are seven variables that were found to have either direct or indirect relationships with the four tested outcome variables. By presenting a parsimonious set of significant variables, managers may be able to focus their improvement efforts based on a much smaller set of factors. On the other hand, one limitation to the research findings is that a great deal of variance is not accounted for in the resultant models. Future research that tests the relationships of additional variables with Sustainability Outcomes could address this limitation. For instance, the continuous improvement literature hypothesizes that several organizational factors and external environmental factors may influence improvement sustainability, including organizational structure and policies (Dale et al., 1997) and competitors (Dale et al., 1997; Keating et al., 1999). These types of organizational and environmental factors were beyond the scope of the present research. However, future research may find that these factors account for some of the variance that is not currently explained in the present models.

Furthermore, there appears to be at least anecdotal evidence to support further exploration of the influence that the implementation focus of a Kaizen event may have on Sustainability Outcomes. This evidence was found through qualitative observations of the highest and lowest events for each outcome variable. Through these observations, the extent to which changes were implementation during the events appeared to be a distinguishing characteristic between the events with the highest vs. the lowest outcome values. Again, these observations were qualitative and somewhat limited because they were post hoc analyses based on a smaller sample size (e.g., ten observations). However, this observation provides support for additional research into the influence that implementation of change, as well as event "type" in general, may have on immediate and long term outcomes. Furthermore, researchers have desired to explore this topic in the past as a part of the OSU-VT research objective but have been unable to undertake the research due to limited samples across different types of events. The present anecdotal evidence appears to provide additional evidence that future research is needed.

Exploration of the implementation focus of a Kaizen event could consider the extent to which certain types of events, e.g., standard work events versus value stream mapping events, have an implementation focus and how the implementation focus of the event may influence both the short and long term effectiveness of the Kaizen event.

6.3 Future Research: Additional Testing of Model Robustness

Additional testing of model robustness could increase the generalizability of the resultant models. Specifically, the research's sample size was limited to 65 Kaizen events across eight organizations. Also, all participating organizations are manufacturing organizations. Studying additional organizations from other industries, including non-manufacturing environments, may increase the robustness of the findings. Collecting T1 perceptual data from work area employees in order to better understand their perceptions of Kaizen event sustainability outcomes and the model variables, especially Work Area Characteristics as they directly relate to the behaviors of the work area employees, may also provide additional insights. Finally, several issues including the variable lapse of time in collecting T0 and T1 data and the maturity of measurement in the targeted work area, including the accuracy and precision of the results, may influence the modeling of certain Sustainability Outcomes, particularly in the study of *result sustainability* and *goal sustainability*. Future research could consider other research approaches that attempt to control for these potential effects. Field quasi-experiments and action research appear to be good choices for the future study of Kaizen event outcome sustainability because they both at least partially preserve the natural setting of the phenomenon. Quasi-experiments allow for some control over a subset of independent variables while still allowing for a higher degree of reality than a laboratory experiment (Davis and Cosenza, 1985). Participatory action research (PAR) includes active involvement of both researchers and practitioners in research activities and can empower practitioners by allowing them to be an equal part of solving problems (Whyte, 1991; Greenwood and Levin, 1998). Both research approaches would begin with assessing a baseline of work area performance. Then, the influence of either intervention could be compared to the baseline performance.

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APPENDIX A: CATEGORIZATIONS OF PUBLICATIONS FOR QUALITY ASSESSMENT

	Academic Investigation	Case Study	Expert Kaizen Event Methodologies	Theory Testing Works	Trade Press	Grand Total
1993		**3**				**3**
Taylor and Ramsey		1				1
Treece		1				1
Vasilash		1				1
1994		**2**				**2**
Tanner and Roncarti		1				1
Wittenberg		1				1
1996	**1**	**2**	**1**			**4**
Defilippo	1					1
Redding		1				1
Rusiniak		1				1
Womack and Jones			1			1
1997	**1**	**6**	**1**		**2**	**10**
Adams et al.		1				1
Heard			1			1
Oakeson		1				1
Patton		1				1
Proctor					1	1
Sheridan		1				1
Taninecz		1				1
Vasilash		1				1
Keys to Success					1	1
Montabon et al.	1					1
1998	**1**	**5**			**2**	**8**
Cuscela		1				1
Klaus		1				1
Lararia					1	1
Larson		1				1
Larson (b)		1				1
Melnyk et al.	1					1
Minton		1				1
Wheatley					1	1
1999	**2**	**2**	**3**		**1**	**8**
Dickerson and Turner	1					1
Foreman and Vargas		1				1
Lararia et al.			1			1
LeBlanc		1				1

McNicols et al.			1			1
Proctor					1	1
Richerson	1					1
What Next After the Kaizen Blitz?			1			1
2000	**1**	**6**			**1**	**8**
David		1				1
Hasek		1				1
Sabatini		1				1
Sheridan		1				1
Vasilash		1				1
White	1					1
Sheridan (b)					1	1
Waste Reduction		1				1
2001	**1**	**2**			**1**	**4**
Bateman and the SMMT Industry Forum	1					1
Bicheno					1	1
Creswell		1				1
Palmer		1				1
2002	**1**	**3**	**3**		**2**	**9**
Bane			1			1
Bateman and David	1					1
Bodek		1				1
Boyer			1			1
Demers					1	1
Mika			1			1
Pritchard		1				1
Watson					1	1
Winning with Kaizen		1				1
2003	**2**	**5**	**1**	**1**	**1**	**10**
Baker		1				1
Bateman and Rich	1					1
Davis					1	1
Doolen et al.	1					1
Kleinsasser		1				1
Patil				1		1
Smith		1				1
Vitalo et al.			1			1
Blake and Eash		1				1
Get Smart, Get Lean		1				1
2004	**3**	**6**	**2**	**1**	**2**	**14**
Bradley and Willet		1				1
Clark		1				1
Cork					1	1
Drickhamer					1	1
Farris et al.	1					1

	C1	C2	C3	C4	C5	Total
Harvey			1			1
Jusko		1				1
Kosandal and Farris	1					1
Kumar and Harms	1					1
Lanigan		1				1
Martin			1			1
Miller				1		1
Purdum		1				1
Drickhamer (b)		1				1
2005	**1**	**3**	**4**	**1**	**3**	**12**
Bateman				1		1
Destefani		1				1
Diana					1	1
Farris and Van Aken			1			1
Goldacker			1			1
Huls			1			1
Koenigsaecker			1			1
Maurer					1	1
Montabon	1					1
Venables					1	1
Vonk		1				1
Scanning CMM: Increases Productivity		1				1
2006	**3**	**1**		**1**	**3**	**8**
Alukal					1	1
Chapman					1	1
Cveykus and Carter		1				1
Farris				1		1
Farris et al.	1					1
Farris et al. (b)	1					1
Letens et al.	1					1
Ortiz					1	1
2007	**7**	**4**	**4**	**1**	**7**	**23**
Cross		1				1
Cunningham and Smith		1				1
Doolen et al.	1					1
Farris et al.				1		1
Farris et al. (b)	1					1
Flint		1				1
Gaboury					1	1
Glover	1					1
Hale and Kubiak					1	1
Harms			1			1
Hawkins					1	1
Johnson et al.		1				1
Langer					1	1
Lee					1	1

Lewis					1	1
Magdum and Whitman	1					1
Manos			1			1
Martin			1			1
Martin and Osterling			1			1
Scheel et al.	1					1
Wickiser					1	1
Worley et al.	1					1
Farris et al. (c)	1					1
2008	**6**	**2**		**4**	**2**	**14**
Adamson and Kwolek		1				1
Burch				1		1
Devens et al.	1					1
Doolen et al.	1					1
Farris et al.	1					1
Glover	1					1
Glover et al.				1		1
Glover et al. (b)				1		1
Liu and Farris				1		1
Liu et al.					1	1
Radnor and Walley	1					1
Sprovieri					1	1
Tatikonda		1				1
Worley et al.	1					1
2009	**10**	**3**		**2**		**15**
Barraza et al.	1					1
Blanchard		1				1
Dentz et al.	1					1
Dickson et al.	1					1
Farris et al.				1		1
Farris et al. (b)				1		1
Glover	1					1
Liu et al.	1					1
Liu et al. (b)	1					1
Loyd et al.	1					1
Marin-Garcia et al.	1					1
Martin et al.	1					1
Nahmens	1					1
Rumpza		1				1
Business Stationery Completes First Lean Kaizen Event		1				1
Grand Total	**40**	**55**	**19**	**11**	**27**	**152**

APPENDIX B: KAIZEN EVENT PUBLICATIONS IDENTIFIED IN SYSTEMATIC LITERATURE REVIEW

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APPENDIX C: POST EVENT INFORMATION SHEET: SURVEY INSTRUMENT USED IN PRESENT RESEARCH

Hello Research Partner,

Your help is needed on this important research. This questionnaire is part of a research project sponsored by the National Science Foundation. The research studies the effects of Kaizen events over time and what management actions help sustain Kaizen event results. Your company is one of the few companies chosen for the research and will get first access to the research findings. You will be able to use the findings to design better methods for sustaining Kaizen event results.

This questionnaire asks for information about the [insert name of Kaizen event] on [insert event dates] that targeted [insert work area name]. It should take about 30 minutes to complete.

Participation in this research is voluntary. You may decline to answer any question(s) you choose. If you are having difficulty answering some of the questions, please contact Eileen Van Aken (evanaken@vt.edu, 540-231-2780).

Thank you for your help in this important research! If you have any questions or comments, please contact please contact Eileen Van Aken (evanaken@vt.edu, 540-231-2780).

If you have questions about your rights as a research participant, you should contact the Virginia Tech Institutional Review Board (IRB) Human Protections Administrator at Carmen Green (ctgreen@vt.edu, 540-231-4358).

Post-Event Information Sheet

1. **Event Name:**

2. **Dates:**

3. **Progress on Team Goals**

Please indicate the **<u>current level</u>** of performance on each of the goals of the [insert name of Kaizen event] team.

This should include a **<u>numeric estimate</u>** of performance levels (e.g., "current setup time is 4.0 minutes"), if possible. If a numeric estimate is <u>not</u> possible, please provide a short description of current results versus goals (e.g., "the layout we developed was not implemented"). See example below.

EXAMPLE Team Goal	EXAMPLE Results at End of Kaizen Event	EXAMPLE Current Performance Level
1. Reduce setup time to 3 minutes	1. Setup time reduced to 2.5 minutes	1. Setup time currently at 6 minutes
2. Create a new layout for the XYZ work area.	2. New layout created.	2. The new layout has not been implemented.
3. Standardize the lubrication process for machine X	3. New standard procedures created.	3**.** Standard procedures are still in use and have been further improved since the event (action initiated by work area employees).

The [insert name of Kaizen event]:

Team Goal	Results at End of Kaizen Event	Current Performance Level
1.	1.	1.
2.	2.	2.
3.	3.	3.
4.	4.	4.
5.	5.	5.
6.	6.	6.
7.	7.	7.
8.	8.	8.
9.	9.	9.
10.	10.	10.

Select the response that BEST describes your opinion.	Strongly Disagree	Disagree	Tend to Disagree	Tend to Agree	Agree	Strongly Agree
1. At the time of the [insert name of Kaizen event], I believed the team's goals were difficult.	1☐	2☐	3☐	4☐	5☐	6☐
2. *Now*, I believe the team's goals were difficult.	1☐	2☐	3☐	4☐	5☐	6☐
3. At the time of the [insert name of Kaizen event], I believed the event was a good strategy for the organization.	1☐	2☐	3☐	4☐	5☐	6☐
4. *Now*, I believe the event was a good strategy for the organization.	1☐	2☐	3☐	4☐	5☐	6☐
5. *Now*, I believe the changes identified in the [insert name of Kaizen event] were realistic for day-to-day operations.	1☐	2☐	3☐	4☐	5☐	6☐
6. *Now*, I believe the estimated results at the end of the [insert name of Kaizen event] were accurate.	1☐	2☐	3☐	4☐	5☐	6☐
7. *Now*, I believe that, overall, the [insert name of Kaizen event] was a success.	1☐	2☐	3☐	4☐	5☐	6☐

4. Work Area Impact

A. Please choose your response based on your CURRENT opinion of the overall impact of the [insert name of Kaizen event] on [insert work area name].

In your ratings, please consider all changes made as a **direct result** of the event (either during the event itself or after the event). However, please do NOT consider changes made as a result of any additional Kaizen events or other improvement activities after the [insert name of Kaizen event] on [insert event dates].

Select the response that BEST describes your CURRENT opinion of the impact of the [insert name of Kaizen event]	Strongly Disagree	Disagree	Tend to Disagree	Tend to Agree	Agree	Strongly Agree
1. The [insert name of Kaizen event] has had a positive effect on [insert work area name].	1☐	2☐	3☐	4☐	5☐	6☐
2. [Insert work area name] has improved measurably as a result of the [insert name of Kaizen event].	1☐	2☐	3☐	4☐	5☐	6☐
3. The [insert name of Kaizen event] has improved the performance of [insert work area name].	1☐	2☐	3☐	4☐	5☐	6☐
4. In general, the [insert name of Kaizen event] has improved [insert work area name] *management's* attitude toward Kaizen events.	1☐	2☐	3☐	4☐	5☐	6☐

Select the response that BEST describes your CURRENT opinion of the impact of the [insert name of Kaizen event]	Strongly Disagree	Disagree	Tend to Disagree	Tend to Agree	Agree	Strongly Agree
5. In general, the [insert name of Kaizen event] has increased [insert work area name] *management's* belief in the value of Kaizen events	1☐	2☐	3☐	4☐	5☐	6☐
6. In general, the [insert name of Kaizen event] has increased [insert work area name] *employees'* belief that Kaizen events serve an important purpose.	1☐	2☐	3☐	4☐	5☐	6☐
7. In general, the [insert name of Kaizen event] has increased [insert work area name] *employees'* belief in the value of Kaizen events	1☐	2☐	3☐	4☐	5☐	6☐
8. In general, the [insert name of Kaizen event] has increased [insert work area name] *employees'* willingness to be part of Kaizen events in the future.	1☐	2☐	3☐	4☐	5☐	6☐
9. In general, the [insert name of Kaizen event] has increased [insert work area name] *employees'* belief that Kaizen events are a good strategy for this organization.	1☐	2☐	3☐	4☐	5☐	6☐
10. In general, the [insert name of Kaizen event] has improved [insert work area name] *employees'* attitudes toward Kaizen events.	1☐	2☐	3☐	4☐	5☐	6☐

Select the response that BEST describes your CURRENT opinion of the impact of the [insert name of Kaizen event]	Strongly Disagree	Disagree	Tend to Disagree	Tend to Agree	Agree	Strongly Agree
11. In general, the [insert name of Kaizen event] has increased [insert work area name] *employees'* belief that Kaizen events are needed in this organization.	1☐	2☐	3☐	4☐	5☐	6☐

B. Please choose the response that BEST describes your opinion

Select the response that BEST describes your opinion.	Strongly Disagree	Disagree	Tend to Disagree	Tend to Agree	Agree	Strongly Agree
1. *Initially*, the [insert name of Kaizen event] resulted in changes to work methods in [insert work area name].	1☐	2☐	3☐	4☐	5☐	6☐
2. *Initially*, the *management* of [insert work area name] accepted the changes made as a result of the [insert name of Kaizen event].	1☐	2☐	3☐	4☐	5☐	6☐
3. *Initially*, the *management* of [insert work area name] held employees accountable for following the new work methods from the [insert name of Kaizen event].	1☐	2☐	3☐	4☐	5☐	6☐
4. *Now*, the *management* of [insert work area name] accepts the changes made as a result of the [insert name of Kaizen event].	1☐	2☐	3☐	4☐	5☐	6☐

Select the response that BEST describes your opinion.	Strongly Disagree	Disagree	Tend to Disagree	Tend to Agree	Agree	Strongly Agree
5. *Now*, the *management* of [insert work area name] holds employees accountable for following the new work methods from the [insert name of Kaizen event].	1☐	2☐	3☐	4☐	5☐	6☐
6. *Initially, employees* in [insert work area name] accepted the changes made as a result of the [insert name of Kaizen event].	1☐	2☐	3☐	4☐	5☐	6☐
7. *Initially, employees* in [insert work area name] followed the new work methods from the [insert name of Kaizen event].	1☐	2☐	3☐	4☐	5☐	6☐
8. *Now, employees* in [insert work area name] accept the changes made as a result of the [insert name of Kaizen event].	1☐	2☐	3☐	4☐	5☐	6☐
9. *Now, employees* in [insert work area name] follow the new work methods from the [insert name of Kaizen event].	1☐	2☐	3☐	4☐	5☐	6☐
10. *Now*, the improvements made during the [insert name of Kaizen event] have been sustained.	1☐	2☐	3☐	4☐	5☐	6☐

C. **Not** including closing out follow-up action items from the [insert name of Kaizen event], have any further improvement activities been conducted **as a result of** the [insert name of Kaizen event]**?**

1 ☐ = YES   (please specify:)   2 ☐ = NO

	Not at all	To a small extent	To some extent	To a moderate	To a large extent	To a great extent
If you selected YES, please rate the extent to which these <u>additional activities</u> have resulted	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐

D. Please choose your response based on your CURRENT opinion of [insert work area name] work environment.

Select the response that BEST describes your CURRENT opinion of [insert work area name] work group.	Strongly Disagree	Disagree	Tend to Disagree	Tend to Agree	Agree	Strongly Agree
1. [insert work area name] employees believe there is a need for continuous improvement in [insert work area name].	1☐	2☐	3☐	4☐	5☐	6☐
2. [insert work area name] employees try out new things by applying them in practice.	1☐	2☐	3☐	4☐	5☐	6☐
3. [insert work area name] employees try to think how the different parts of the organization fit together.	1☐	2☐	3☐	4☐	5☐	6☐
4. [insert work area name] employees feel a sense of accountability for the work they do.	1☐	2☐	3☐	4☐	5☐	6☐
5. [insert work area name] employees ask each other for help when they need assistance.	1☐	2☐	3☐	4☐	5☐	6☐
6. [insert work area name] employees understand how their work fits into the "bigger picture" of the organization.	1☐	2☐	3☐	4☐	5☐	6☐
7. [insert work area name] employees understand what continuous improvement is.	1☐	2☐	3☐	4☐	5☐	6☐
8. [insert work area name] employees want to do what is best for the organization.	1☐	2☐	3☐	4☐	5☐	6☐
9. [insert work area name] employees freely share information with one another.	1☐	2☐	3☐	4☐	5☐	6☐
10. [insert work area name] employees feel a shared sense of responsibility for the work they do.	1☐	2☐	3☐	4☐	5☐	6☐

Select the response that BEST describes your CURRENT opinion of [insert work area name] work group.	Strongly Disagree	Disagree	Tend to Disagree	Tend to Agree	Agree	Strongly Agree
11. [insert work area name] employees test new ideas to help themselves learn.	1☐	2☐	3☐	4☐	5☐	6☐
12. [insert work area name] employees understand how continuous improvement can be applied to [insert work area name].	1☐	2☐	3☐	4☐	5☐	6☐
13. [insert work area name] employees understand how their work relates to that of other parts of the organization.	1☐	2☐	3☐	4☐	5☐	6☐
14. [insert work area name] employees believe they have a role in continuous improvement in [insert work area name]	1☐	2☐	3☐	4☐	5☐	6☐
15. [insert work area name] employees ask each other questions when they are uncertain about something.	1☐	2☐	3☐	4☐	5☐	6☐

5. Work Area History

Please list the <u>name</u>, the <u>start date (MM/DD/YY)</u> and the <u>primary objective(s)</u> of any other Kaizen events that have occurred in [insert work area name] **AFTER** the [insert name of Kaizen event] on [insert event dates].

 Please also rate the relative success of each of these events, using the scale 1 = "very unsuccessful" to 6 = "very successful," based on your CURRENT opinion.

Kaizen Event Name	Start Date (MM/DD/YY)	Primary Objective(s)	Very Unsuccessful	Unsuccessful	Somewhat Unsuccessful	Somewhat Successful	Successful	Very Successful
Ex. ABC SMED	*09/20/04*	*Reduce setup time of ABC machine*	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
1.			1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
2.			1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
3.			1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
4.			1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐

How many employees currently work in [insert work area name]?

Approximately, how many of current [insert work area name] employees were working in [insert work area name] at the time of the [insert name of Kaizen event] on [insert event dates]?

Has [insert work area name] management changed since [insert name of Kaizen event]?
1 ☐ = YES (please describe personnel changes – what roles and when:)   2 ☐ =NO

Have the current [insert work area name] managers <u>all</u> participated in <u>at least one</u> Kaizen event?
1 ☐ = YES   2 ☐ =NO

At the time of the [insert name of Kaizen event] on [insert event dates], had [insert work area name] managers all participated in at least one Kaizen event?

1 ☐ = YES   2 ☐ =NO

Have there been any other MAJOR CHANGES in [insert work area name] since the [insert name of Kaizen event] on [insert event dates]? **Please Select ALL changes that have occurred since [insert event dates]:**

    ☐ Major change in equipment (please briefly describe:)

    ☐ Major change in [insert work area name] volume

    ☐ Major change in [insert work area name] product mix (please specify:)

    ☐ Other (please specify:)

6. Follow-Up Activities

Immediately after the [insert name of Kaizen event], were there any follow-up action items (or
   "Kaizen newspaper items") that still needed to be completed**?** 1 ☐ = YES   2 ☐ = NO

IF you answered YES above, please select the response that BEST describes the current
   status of these follow-up action items:

1 ☐ = All follow-up action items have been fully completed.
      <u>Please provide</u> an estimated completion date for the last action item

2 ☐ = Not all follow-up action items have been fully completed and the organization IS
currently working
      on completing action items
      <u>Please provide</u> an estimated completion date for the last remaining action item

---

      <u>Please provide</u> a brief description of what the organization is currently doing to

      promote the completion of action items? (e.g., allowing work time towards

      completion of action items, holding follow-up status meetings, etc.)

      3 ☐ = Not all follow-up action items have been fully completed and the organization IS
NOT currently

      working on completing these action items
      <u>Please provide</u> a brief explanation of why the organization is <u>not</u> currently

      working on completing the action items? (e.g., no longer relevant, etc.)

Please rate **the extent** to which each of the following activities has occurred since the completion of the [insert name of Kaizen event] on [insert date of completion of Kaizen event or date of previous post-event information sheet completion].

Select the response that BEST describes your opinion of the extent to which each of the following activities has occurred since the completion of the [insert name of Kaizen event] on [insert date of completion of Kaizen event or date of previous post-event information sheet completion].	Not at all	To a small extent	To some extent	To a moderate extent	To a large extent	To a great extent
a. Formal documentation of follow-up action items (e.g., through a Kaizen newspaper)	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
b. Individual team members working on follow-up action items from the [insert	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
c. The [insert name of Kaizen event] team meeting as a whole to review progress	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
d. Meetings with higher-level management about [insert name of Kaizen event]	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
e. Meetings with Kaizen coordinator or facilitator about [insert name of Kaizen	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
f. Meetings with [insert work area name] management about [insert name of Kaizen	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
g. Training [insert work area name] employees in new work methods and processes from	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
h. Involving [insert work area name] employees (not on the [insert name of	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
i. Updating work method and process documentation (e.g., standard work charts,	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
j. Regularly reviewing performance data related to [insert name of Kaizen event]	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
k. Conducting regular audits on changes made due to the [insert name of Kaizen event].	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐

Select the response that BEST describes your opinion of the extent to which each of the following activities has occurred since the completion of the [insert name of Kaizen event] on [insert date of completion of Kaizen event or date of previous post-event information sheet completion].	Not at all	To a small extent	To some extent	To a moderate extent	To a large extent	To a great extent
If "yes," how often are these audits: daily, weekly, monthly, other (please specify:)						
l. Rewarding or recognizing [insert name of Kaizen event] team members for their	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
m. Rewarding or recognizing [insert work area name] employees (not only those on the [insert name of Kaizen event] team) for	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
n. Avoiding blame or negativity when changes are made, but results are different than	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
o. Avoiding blame or negativity when team goals are not achieved.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
p. Informing higher-level management of issues with follow-up and sustaining results	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
q. Providing [insert work area name] employees with freedom to make changes to	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
r. [Insert work area name] management allowing [insert work area name] employees	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
s. [Insert work area name] management encouraging [insert work area name]	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
t. [Insert work area name] management supporting the use of Kaizen events in the	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
u. [Insert work area name] management championing the value of continuous	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
v. Other (please specify:)	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
w. Other (please specify:)	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐

Select the response that BEST describes your opinion of the extent to which each of the following activities has occurred since the completion of the [insert name of Kaizen event] on [insert date of completion of Kaizen event or date of previous post-event information sheet completion].	Not at all	To a small extent	To some extent	To a moderate extent	To a large extent	To a great extent
x. Other (please specify:)	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐

Were any of the follow-up activities completed for the [insert name of Kaizen event] **unusual** – that is, not typically part of the event follow-up process?

1 ☐ = YES   2 ☐ = NO

If YES, which follow-up activities were **unusual**?

In your opinion, what have been the biggest <u>obstacles</u> **to date** in sustaining the results from the [insert name of Kaizen event]?

In your opinion, what have been the biggest <u>contributors</u> **to date** in sustaining the results from the [insert name of Kaizen event]?

APPENDIX D: CHARACTERISTICS OF STUDY ORGANIZATIONS

	Org. A	Org. B	Org. C	Org. E	Org. F	Org. G	Org. Q	Org. R
Org. description	Secondary wood product manufacturer	Electronic motor manufacturer	Secondary wood product manufacturer	Specialty equipment manufacturer	Steel component manufacturer	Aerospace engineering and manufacturer	IT component manufacturer	Aerospace engineering and manufacturer
SIC code	2434	3621	2434	3843	3443	3721	3577	3721
Public/private	Public	Public	Public	Private	Private	Public	Public	Public
Year founded	1946	1985	1946	1964	1913	1916	1939	1916
No. employees	560	700	500	950	3500	153,000	321,000	153,000
First Kaizen event	1998	2000	1992	2000	1995	1993	2004	1998
Event rate during research	2–3 per month	1 per month	2 per month	6-8 per month	1 per month	4 per week	2 per month	4 per week
Percent of org. experiencing events	100%	90%	Data not available	100%	20%	70%	10%	100%
Major processes targeted	Operations	Operations, sales and marketing, customer service and technical support, product design, production planning and inventory control, process design	Operations	All areas of organization	Manufacturing, order entry, accounts receivable, distribution, vendors, engineering product development	All areas of organization	Manufacturing, test	All areas of organization
Percent of events in manufacturing areas	Almost 100% manufacturing	75% manufacturing	Almost 100% manufacturing	Data not available	80-85% manufacturing	70% manufacturing	95% manufacturing	60% manufacturing

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APPENDIX E: TABLE OF FINAL SET OF EVENTS STUDIED BY COMPANY

Code: TPM = Total Productive Maintenance; PI = (General) Process Improvement; SMED = Setup Reduction;
VSM = Value Stream Mapping; 5S = Housekeeping/Work Area Organization; L = Layout

Companies D, T, U, V, W, X, and Y are excluded from the sample and this appendix due to incomplete data at T0 or T1

Company A: Secondary wood product manufacturer

Event	Dates	Method(s)	Target System	Focus	Team Size	Response Kickoff	Response Report Out	Goal Achievement	Result Sustainability
1. TPM 1A (501)	10/23/05 – 10/28/05	TPM	One Machine	Improving the condition of the target machine and training operators in TPM	5	5 (100%)	4 (80%)	1.00	0.97
2. PI 1A (502)	10/31/05 – 11/04/05	Standard Work	Manufacturing Process	Identifying root causes of scrap and implementing countermeasures	6	6 (100%)	5 (83%)	1.00	1.00
3. PI 2A (504)	12/05/05 – 12/08/05	Process Flow, SMED	Manufacturing Process	Improving the material flow of small lot sizes through a bottleneck process	11	10 (91%)	8 (73%)	1.00	0.84
4. TPM 2A (505)	12/12/05 – 12/1605	TPM	One Machine	Improving the condition of the target machine and training operators in TPM	4	2 (50%)	4 (100%)	1.00	0.99
5. TPM 3A (506)	01/08/06 – 01/1106	TPM	Three Machines	Improving the condition of the target machines and training operators in TPM	7	7 (100%)	6 (86%)	1.00	1.00
6. SMED 1A (509)	01/16/06 – 01/20/06	SMED	One Machine	Reducing changeover times for machine	8	8 (100%)	6 (75%)	0.97	0.40

#	Event	Date	Tools	Target	Objective					
7.	SMED 2A (510)	01/23/06 – 01/27/06	SMED, 5S	One Machine	Reducing changeover times for machine	5	5 (100%)	4 (80%)	0.96	0.97
8.	PI 3A (512)	02/06/06 – 02/14/06	None	Manufacturing Process	Improving material flow through the manufacturing process	10	9 (90%)	8 (80%)	1.00	1.00
9.	TPM 4A (514)	03/13/06 – 03/17/06	TPM	Two Machines	Improving the condition of the target machines and training operators in TPM	7	6 (86%)	6 (86%)	1.50	1.00
10.	PI 4A (517)	03/21/06 – 03/23/06	None/ Brainstorming	Manufacturing Process/ Department	Creating a future state layout for target department and developing an implementation plan	4	4 (100%)	4 (100%)	1.00	0.88
11.	PI 5A (520)	03/27/06 – 03/30/06	Six Sigma	Manufacturing Process	Creating a future state layout for target process and developing an implementation plan	6	6 (100%)	6 (100%)	1.00	0.00
12.	TPM 5A (521)	04/24/06 – 04/28/06	TPM	Two Machines	Improving the condition of the target machines and training operators in TPM	5	5 (100%)	4 (80%)	1.00	1.03
13.	PI 6A (523)	05/01/06 – 05/05/06	None	Manufacturing Process/ Department	Prepare a designated location for two new pieces of machinery (location decided in advance of event)	6	6 (100%)	4 (67%)	1.00	0.67
14.	PI 7A (532)	05/15/06 – 05/18/06	SMED	Family of machines	Establishing standard setup and inspection procedures for target machines, including developing training aids for setups	5	4 (80%)	3 (60%)	1.00	1.00
15.	PI 8A (530)	05/22/06 – 05/26/06	None	Manufacturing Process/	Laying out a cell for a new product line	6	4 (67%)	4 (67%)	1.00	0.98

			Department	and installing equipment in cell					
16. TPM 9A (547)	6/24/07 – 6/29/07	TPM	One Machine	Improving the condition of the target machines and training operators in TPM	6	6(100%)	6(100%)	1.00	1.00
17. 5S 10A (548)	8/6/07- 8/10/07	5S	Manufacturing Support	Improving the organization of the targeted work area	5	4(80%)	4(80%)	1.29	0.88
18. PI 11A (549)	9/24/07- 9/28/07	None	Manufacturing Process/ Department	Improving equipment standards and process control in the targeted work area	9	5(55%)	5(55%)	1.00	1.00
19. PI 12A (550)	11/15/07- 11/20/07	7 Principles of Warehousing	Inventory Storage Area	Reducing and updating the inventory to reflect the current production mix	10	8(80%)	6(60%)	1.28	1.14

Company B: Electronic motor manufacturer

Event	Dates	Method(s)	Target System	Focus	Team Size	Response Kickoff	Response Report Out	Goal Achievement	Result Sustainability
1. PI 1B (319)	03/28/06 – 03/30/06	TPI	Service process	Improving and standardizing the inquiry to quote process for standard product lines	12	9 (75%)	11 (92%)	1.00	0.49
2. VSM 1B (322)	04/03/06 - 04/05/06	VSM	Manufacturing process (product repair)	Creating a current state map of target process (repair process) and identify general areas/triggers for improvement	11	11 (100%)	9 (82%)	1.00	1.00
3. PI 2B (324)	05/08/06 – 05/12/06	Standard Work	Manufacturing process	Reducing cell lead-time	22	14 (64%)	11 (50%)	1.00	PEIS partially completed
4. PI 3B (325)	05/08/06 – 05/12/06	Standard Work	Manufacturing process	Redesigning cell layout to meet a specified takt rate	8	6 (75%)	6 (75%)	0.80	PEIS not collected

Event	Dates	Method(s)	Target System	Focus	Team Size	Response Kickoff	Response Report Out	Goal Achievement	Result Sustainability
5. PI 4B (326)	05/08/06 – 05/12/06	Standard Work	Manufacturing process	Redesigning cell layout to meet a specified takt rate	10	9 (90%)	6 (60%)	1.43	PEIS not collected
6. PI 5B (327)	05/08/06 – 05/12/06	Standard Work	Manufacturing process	Simplifying the process and reducing changeover times	11	9 (73%)	6 (55%)	0.20	PEIS not collected
7. PI 6B (328)	05/08/06 – 05/12/06	Standard Work	Manufacturing process	Improving material and information flow within the cell	20	19 (95%)	16 (80%)	0.34	0.89
8. PI 7B (329)	05/08/06 – 05/12/06	Standard Work	Service process	Reducing time for fax filing and distribution	7	7 (100%)	6 (86%)	1.00	1.00
9. PI 8B (346)	10/10/06 - 10/13/06	Lean Conversion, Standard Work	Manufacturing process	Completing a lean conversion of the work area including the implementation of cellular production, standard work, and point of use inventoy	14	12(86%)	7(50%)	1.00	PEIS not collected

Company C: Secondary wood product manufacturer

Event	Dates	Method(s)	Target System	Focus	Team Size	Response Kickoff	Response Report Out	Goal Achievement	Result Sustainability
1. PI C1 (615)	01/09/06 – 01/13/06	None/JIT and Kaizen	Manufacturing process common across multiple product lines	Balancing the line using a certain bottleneck machine as pacesetter for takt time	11	8 (73%)	9 (82%)	1.00	1.00
2. PI C2 (634)	1/23/06 - 1/27/06	None	Manufacturing process	Increasing process flexibility and reducing batching by replacing two dedicated machines with a more flexible model	8	8 (100%)	7 (88%)	0.50	0.00
3. PI C4 (618)	2/27/06 - 3/3/06	Standard Work	Manufacturing process	Determining job standards for cell and training operators to meet standards (task improvement and allocation)	9	9 (100%)	5 (56%)	1.00	PEIS not collected

#	Event	Dates	Method	Scope	Objective					
4.	PI C5 (616)	3/13/06 - 3/17/06	Standard Work	Manufacturing process	Determining job standards for cell and training operators to meet standards (task improvement and allocation)	7	7 (100%)	7 (100%)	0.50	PEIS not collected
5.	PI C6 (641)	3/27/06 - 3/31/06	None	Manufacturing process	Reducing lead-time variance across different products	5	5 (100%)	3 (60%)	1.00	1.00
6.	PI C3 (635)	2/13/06 - 2/20/06	Standard Work	Manufacturing process	Determining job standards for cell and training operators to meet standards (task improvement and allocation)	8	8 (100%)	3 (38%)	1.00	Event removed from initial analysis
7.	PI C7 (636)	4/10/06 - 4/14/06	Standard Work and DMAIC	Manufacturing process common across multiple product lines	Reducing defects	4	0 (0%[1])	0 (0%)	1.00	Event removed from initial analysis
8.	PI C8 (637)	4/24/06 - 4/28/06	None/ continuous flow	Manufacturing process	Reducing cycle time	5	5 (100%)	2 (40%)	1.00	Event removed from initial analysis
9.	5S 1C (638)	5/8/206 - 5/12/06	5S	Manufacturing process/department	Improving inventory management and reducing defects	4	2 (50%)	3 (60%)	1.00	Event removed from initial analysis
10.	PI C9 (639)	5/22/06 - 5/26/06	None/7 wastes and waste reduction, lean line design and kanban systems	Manufacturing process	Improving process flow and area staffing requirements	5	5 (100%)	4 (80%)	1.00	1.00
11.	5S 2C (640)	6/12/06 - 6/16/06	5S	Manufacturing process/department	Improving inventory management and reducing part retrieval time	5	5 (100%)	0 (0%)	1.00	Event removed from initial analysis

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[1] A response rate of zero percent indicates that none of these surveys were returned by organization

Company E: Specialty equipment manufacturer

Event	Dates	Method(s)	Target System	Focus	Team Size	Response Kickoff	Response Report Out	Goal Achievement	Result Sustainability
1. PI 1E (100)	12/20/05 – 12/22/05	Cellular Design	Manufacturing process/ Department	Redesigning cell layout to improve product flow and reduce cycle time	4	3 (75%)	3 (75%)	0.85	1.00
2. PI 2E (104)	03/14/06 – 03/17/06	Standard Work and Process Mapping	Service process	Reducing cycle time of customer quote process	8	7 (88%)	4 (50%)	2.34	1.32
3. VSM 1E (101)	3/14/06 – 3/16/06	VSM	Service process	Documenting the current state, designing a future state and identifying future Kaizen events to implement future state	4	4 (100%)	4 (100%)	1.00	Event removed from initial analysis
4. SMED 1E (102)	03/20/06 – 03/22/06	SMED	One machine	Reducing changeover time for target machine	5	5 (100%)	5 (100%)	0.56	N/A[2]
5. PI 3E (106)	03/28/06 - 03/31/06	Standard Work	Manufacturing support process (ordering)	Improving part ordering process to reduce part shortages	5	5 (100%)	5 (100%)	1.75	1.00
6. PI 4E (103)	04/03/06 – 04/05/06	None	Manufacturing process	Reducing lead-time and implementing one piece flow	4	4 (100%)	4 (100%)	0.94	1.00
7. VSM 2E (107)	04/17/06 - 04/19/06	VSM	Manufacturing /shipping process	Improving shipping ("kitting") process to eliminate omissions in orders	5	4 (80%)	4 (80%)	1.00	1.00
8. PI 5E	04/24/06 -	Standard	Manufacturing	Reducing defects	8	7 (88%)	6 (75%)	1.25	PEIS not

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[2] N/A indicates that there was inadequate information in the EIS or PEIS to calculate this measure

(105)	04/28/06	Work	process						collected
9. PI 6E (108)	05/16/06 – 05/18/06	Standard Work	Manufacturing process	Reducing cycle time	6	5 (83%)	5 (83%)	0.38	1.00
10. PI 7E (109)	06/13/06 – 06/15/06	Process Mapping, Flow	Manufacturing support process (ordering)	Reducing cycle time of ordering process	7	6 (86%)	5 (71%)	0.83	1.00
11. SMED 2E (111)	6/22/06 – 6/23/06	SMED	One machine	Reducing changeover time for target machine	5	5 (100%)	5 (100%)	0.90	0.92
12. PI 9E (112)	8/1/06 - 08/3/06	Brainstorming, 5S, Standard Work, Cellular Design, Kanban Systems, magnet board, and Processing Mapping	Manufacturing process	Reduce throughput, improve flow, and reduce ergonomic issues of the target process	6	6(100%)	5(83%)	0.93	1.00
13. PI 10E (113)	8/7/06 - 8/10/06	None	Manufacturing support	Streamline targeted process and reduce waste	7	5(71%)	5(71%)	0.50	1.11
14. PI 11E (114)	8/15/06 - 8/17/06	Standard Work, Brainstorming, and Process Mapping	Manufacturing /shipping process	Streamline targeted process and reduce defects and omissions	10	5(50%)	5(50%)	1.00	0.00
15. P1 12E (115)	0/25/07- 09/27/07	None	Manufacturing process	Redesigning cell layout to improve product flow and reduce cycle time	6	5(83%)	5(83%)	0.69	0.86
16. P1 8E (110)	6/26/06 – 6/28/06	Standard Work	Service Process	Reduce process complexity (number of steps) and cycle time for the target process	4	4 (100%)	3 (75%)	0.49	PEIS partially completed

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Company F: Steel component manufacturer

Event	Dates	Method(s)	Target System	Focus	Team Size	Response Kickoff	Response Report Out	Goal Achievement	Result Sustainability
1. L 1F (400)	01/11/06 – 01/12/06	None	Inventory Storage Area	Redesigning the layout of a storage area	7	7 (100%)	7 (100%)	1.00	1.00
2. TPM 1F (401)	03/24/06 – 03/25/06	TPM	One Machine	Developing an autonomous maintenance program for the target machine	6	5 (83%)	5 (83%)	1.00	1.00
3. 5S 1F (402)	03/28/06 – 03/30/06	6S	Manufacturing Process/ Department	Raising 5S (6S) score of target cell	4	4 (100%)	4 (100%)	0.78	1.00
4. 5S 2F (403)	04/17/06 – 04/18/06	6S	Manufacturing Process/ Department	Implementing 5S (6S) to improve organization of target cell	3	3 (100%)	3 (100%)	1.00	0.46
5. PI 1F (404)	05/10/06 – 05/12/06	None	Manufacturing Process	Documenting current state (operation times, etc.) and improving material flow through the target process	8	8 (100%)	8 (100%)	1.00	0.75
6. TPM 2F (405)	05/12/06 – 05/13/06	TPM	One Machine	Developing an autonomous maintenance program for the target machine	6	6 (100%)	6 (100%)	1.00	1.00
7. TPM 3F (406)	10/12/06 - 10/14/06	TPM	One Machine	Developing an autonomous maintenance program for the target machine	6	5(83%)	5(83%)	0.56	0.67

Company G: Aerospace engineering and manufacturer

Event	Dates	Method(s)	Target System	Focus	Team Size	Response Kickoff	Response Report Out	Goal Achievement	Result Sustainability
1. PI 1G (1800)	10/2/06 - 10/6/06	None	Manufacturing (Assembly) Process	Reducing flow time and reliability of product assembly process	29	21(72%)	16(55%)	1.00	1.00
2. L 1G (1802)	11/27/07 - 11/30/07	3P (Production Preparation Process)	Manufacturing (Assembly) Process	Redesigning production line layout to reduce cycle time	42	39(93%)	30(71%)	1.00	0.00
3. PI 2G (1804)	11/26/07 - 11/30/07	7 wastes and waste reduction exercise	Manufacturing support process (product testing)	Reducing testing failures and refining testing equipment	13	7(54%)	10(77%)	1.00	0.50
4. PI 3G (1805)	3/3/08 - 3/7/08	None	Manufacturing (Assembly) Process	Reducing rework, repair, and scrap	9	8(89%)	9(100%)	N/A	N/A
5. PI 4G (1806)	3/3/08 - 3/7/08	None	Manufacturing (Assembly) Process	Improving tooling used in the targeted process	9	9(100%)	5(56%)	1.00	1.40
6. PI 5G (1807)	3/10/08 - 3/14/08	None	Manufacturing (Assembly) Process	Standardizing the assembly process and improving supplier and internal quality	10	9(90%)	10(100%)	1.00	1.40
7. PI 6G (1808)	3/10/08 - 3/14/08	None	Manufacturing (Assembly) Process/One Machine	Improving an assembly process related to a specific piece of equipment	9	6(66%)	5(56%)	1.00	0.98
8. VSM 1G (1801)	5/7/07 - 5/11/07	VSM	Manufacturing (Assembly) Process	Documenting the current state and designing a future state to improve quality and eliminate duplicate processes	25	22(88%)	9(36%)	1.00	Event removed from initial analysis

Company Q: IT component manufacturer

Event	Dates	Method(s)	Target System	Focus	Team Size	Response Kickoff	Response Report Out	Goal Achievement	Result Sustainability
1. PI 1Q (1700)	5/1/06 - 5/5/06	None	Manufacturing process/department	Reducing waste in targeted work area by reducing lead time variability, throughput, operator travel, etc.	13	13(100%)	13(100%)	0.60	0.80
2. PI 3Q (1702)	9/17/07 - 9/21/07	None	Manufacturing process/department	Reducing non-value-added activities/waste and improving costs and processing time	12	12(100%)	12(100%)	0.92	0.91
3. PI 4Q (1703)	10/22/07 - 10/25/07	5S, Standard work, SMED	Manufacturing process/department	Reducing steps, processing time, errors, and waste and implementing visual controls, etc.	9	9(100%)	8(89%)	1.02	0.73
4. PI 5Q (1704)	3/3/08 - 3/7/08	None	Manufacturing support process/department	Reducing processing and travel time and implementing visual controls	10	10(100%)	10(100%)	0.73	0.96
5. PI 6Q (1705)	4/21/08 - 4/25/08	None	Manufacturing support process/department	Reducing processing and travel time and implementing visual controls	13	12(92%)	12(92%)	0.76	1.00
6. PI 2Q (1701)	9/18/06 - 9/22/06	5S, Standard Work, SMED, Visual Controls	Manufacturing process/department	Reducing lead time variability, throughput time, operator travel, etc. and increasing productivity	12	12(100%)	11(92%)	N/A	PEIS not collected

Company R: Aerospace engineering and manufacturer

Event	Dates	Method(s)	Target System	Focus	Team Size	Response Kickoff	Response Report Out	Goal Achievement	Result Sustainability
1. PI 1R (1900)	10/01/07-10/05/07	3P	Manufacturing (Assembly) Support Process	Improving transportation through factory organization and safety improvement and improved staffing levels to reduce travel times, etc.	21	21(100%)	19(90%)	1.00	0.88
2. PI 4R (1903)	12/3/07 - 12/7/07	None	Manufacturing (Assembly) Support Process	Improving the process of delivering parts and materials to assembly process	13	13(100%)	11(85%)	1.00	1.00
3. PI 5R (1904)	2/18/08 - 2/22/08	None	Manufacturing (Assembly) Process	Improving an assembly process and reducing errors	9	8 (89%)	5 (56%)	1.00	0.50
4. PI 6R (1905)	2/18/08 - 2/22/08	None	Manufacturing (Assembly) Support Process	Standardizing the process of delivering a part to the assembly process	11	11 (100%)	6 (55%)	1.00	0.00
5. PI 7R (1906)	2/18/08 - 2/22/08	Standard Work	Manufacturing (Assembly) Process	Standardizing assembly process, implementing ergonomic, safety, and quality improvements, and reducing cycle time	17	10 (59%)	11 (65%)	0.63	0.63
6. PI 8R (1907)	4/7/08 - 4/11/08	None	Manufacturing (Assembly) Process	Improving process flow and area staffing requirements and standardizing the process	9	9 (100%)	5 (56%)	0.93	0.83
7. PI 2R (1901)	11/14/07-11/16/07	3P	Manufacturing (Assembly) Process	Reducing cycle time	61	45(74%)	25(41%)	0.78	Event removed from initial analysis
8. PI 3R (1902)	12/3/07 - 12/7/07	3P	Manufacturing (Assembly) Process	Reducing overall process flow time	23	15(65%)	9(39%)	1.00	Event removed from initial analysis

APPENDIX F: DESCRIPTIVE STATISTICS OF MODEL VARIABLES

	Continuous Variables					
	Minimum	Maximum	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
Result Sustainability	0.00	1.40	0.85	0.32	-1.51	0.30
Goal Sustainability[a]	-2.00	0.46	-0.20	0.55	-2.82	0.30
Impact on Area Sustainability	0.25	1.57	0.94	0.23	-0.28	0.30
Work Area Attitude and Commitment	2.67	5.83	4.43	0.77	-0.25	0.30
Goal Clarity	3.00	5.56	4.57	0.50	-0.46	0.30
Goal Difficulty	1.92	5.01	3.66	0.64	-0.48	0.30
Team Functional Heterogeneity	0.13	0.82	0.49	0.17	-0.44	0.30
Management Support	3.57	5.67	4.83	0.49	-0.36	0.30
Work Area Routineness	1.75	6.00	4.80	0.91	-1.35	0.30
Learning and Stewardship	2.29	5.86	4.57	0.71	-0.67	0.30
Experimentation and Continuous Improvement	2.50	5.75	4.33	0.74	-0.09	0.30
Employee Change	1.00	6.00	4.00	1.32	-0.57	0.30
Improvement Culture	1.50	5.83	3.53	1.18	-0.05	0.30
Avoiding Blame	1.00	5.60	3.32	1.23	0.09	0.30
Institutionalizing Change	0.00	1.40	0.85	0.32	-1.51	0.30
Performance Review	-2.00	0.46	-0.20	0.55	-2.82	0.30
	Binary and Categorical Variables					
Management Change	Yes=27 No=37					
Production System Changes	No change=43 One change=18 Two changes= 3 Three changes=1					
Management Kaizen event Participation at T0 (dummy variable)	1 of the 65 observed events					
Management Kaizen event Participation at T1 (dummy variable)	8 of the 65 observed events					

[a] Due to strong departures from normality, the original variable was log transformed for modeling purposes; the statistics reported here are based on the transformed values