AN ABSTRACT OF THE RESEARCH PROJECT OF

Bradley Moore for the degree of Master of Science in Industrial Engineering presented on September 23rd, 2015.

Title: Framework and Method for Designing Complementarist Interventions to Systemically Address Management Challenges in Small Organizations.

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Javier Calvo- Amodio

Small organizations may face several management challenges, such as developing non-centralized management structures, knowledge retention in rapid turnover environments, complex operations, and diverse stakeholder requirements. Many methodologies exist to address such management challenges, including viable system model, knowledge management, and Toyota production system, or lean manufacturing. Each of these methodologies addresses a particular management challenge, but none of them alone are sufficient to address the complex problem contexts of modern organizations. Several methodologies also exist to combine different weltanschauungen (worldviews), including soft systems methodology, total systems intervention, creative design of methods, and boundary critique. These are all methodologies in the field of systems thinking, thus their application requires education in that field. Practitioners need support in defining experienced problem contexts, selecting intervention approaches (methodologies), and applying a complementarist intervention approach. This research provides a framework for defining problem contexts and intervention approaches, and a method for selecting appropriate approaches and applying them. The proposed framework and method
were developed in a case study of a small non-profit organization performing knowledge-based work in a dynamic environment. The research is presented in this paper by: 1) discussing the purpose of the research, 2) describing the methodology for developing the framework and method, 3) presenting the three papers within this research, 4) discussing findings and conclusions, and 5) proposing future work.
Framework and Method for Designing Complementarist Interventions to Systemically Address Management Challenges in Small Organizations.

by
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Chapter 1
1 Introduction

1.1 Operational Definitions

There are several words and terms that are used in this research that require definitions.

**Weltanschauung [plural: weltanschauungen]:** A worldview or perspective. A weltanschauung guides methods and outcomes of actions.

**CATWOE:** An acronym for customer, actor, transformation, weltanschauung, owner, environment. This is a tool of Soft Systems Methodology for defining systems of purposeful activity.

**Problem Context:** Also called problem situation. This is a real world scenario that an actor wishes to improve.

**Intervention:** A guided strategy applied in a problem context with a purpose.

**Methodology, Intervention Approach:** Two terms used interchangeably in this research. A theory and practice developed for a certain purpose with a particular weltanschauung.

**Pluralism:** Combining multiple whole methodologies, making them agree in their weltanschauungen.

**Complementarist Approach:** Combining elements of multiple methodologies, using pieces as needed for intervention.
1.2 Background

Systems thinking has become a valuable driver of organizational management. It can be used to gain a holistic perspective of an organization and design appropriate and effective solutions to management challenges (Jackson, 2003). Some systems thinking methodologies are primarily theoretical and do not provide much guidance for practitioners. Additionally, those who are not well educated in the field of systems thinking may find its methodologies inaccessible (Jackson, 2003). Midgley, Munlo, and Brown (1998) discuss a case where systems language created a communication barrier between researchers and organizational management. This presented challenges in comprehension for management and risked creating the impression that researchers were not valuing the perspectives of managers. Systems thinking researchers can benefit organizational managers by designing methods in which systemic practices and concepts are encapsulated. This will allow managers to use and benefit from systemic practices without having education in systems thinking.

Systemic methodologies such as soft systems methodology (SSM), total systems intervention (TSI), creative design of methods (CDM), and boundary critique are concerned with combining multiple world views (weltanschauungen). These methodologies can be applied to combine multiple intervention approaches [in this article “intervention approaches” and “methodologies” can be viewed as interchangeable]. Methodologies are initially developed in given problem contexts, with particular weltanschauungen, for certain purposes. Methods and outcomes of an intervention approach are inspired by its world view (weltanschauung).

A single intervention approach may be insufficient in a complex problem context (Jackson, 2001). Organizations often face several management challenges. Individual intervention approaches may address part of the set of management challenges, but multiple approaches may be necessary for holistic action. Deciding which intervention approaches to apply to a given problem context to address the complete set of challenges may be difficult. Furthermore, deciding how to combine multiple
intervention approaches effectively complicates the problem. The research presented in this paper describes the application method of a framework developed by Moore, Calvo-Amodio, and Junker (2015). The proposed framework and method will guide practitioners in holistically selecting and applying multiple intervention approaches to an experienced problem context without an extensive background in systems thinking.

1.3 Problem Statement

Some organizational management challenges are internally-driven, such as adhering to non-profit budgets, applying knowledge to complete work tasks, and creating management structures to sustain viable operations. Conversely, some challenges are environmentally-driven, such as maintaining knowledge despite rapid turnover of the workforce and meeting diverse stakeholder demands. If organizational performance is to be improved, internal and external challenges must be addressed. Without guided intervention approaches, ad hoc management initiatives can have detrimental effects (Jackson, 2003). Ad hoc structures prohibit organizations from reaching their full potential by not fully utilizing collaborative potential (Bryan, Matson, & Weiss, 2007). When collaboration is poor, organizational performance suffers due to poor utilization of knowledge (Mohamed, Stankosky, & Murray, 2004). Sy and D’Annunzio (2005) found that matrix organizations often suffer from misaligned goals, unclear roles and responsibilities, ambiguous authority, lack of matrix guardian, and silo-focused employees. A holistic framework for management intervention would help inform managers of more effective practices to improve performance through (Jackson, 2003).

As a starting point, consider a non-profit service organization that performs knowledge-based project work in a dynamic environment. In this case, a matrix organizational structure is likely to be used as it combines the benefits of functional and project structures (Sy & D’Annunzio, 2005). Such an organization faces several management challenges such as the necessity for a non-centralized management
structure, knowledge retention, and meeting diverse stakeholder demands. Three intervention approaches that are designed for such problem contexts are viable system model (VSM), knowledge management (KM), and Toyota production system (TPS; also known as lean manufacturing).

There are several intervention approaches to address management challenges, such as VSM, KM, TPS, SSM, operations research, and organizational behavior. These were developed in different problem contexts, with different weltanschauungen, to achieve various outcomes. The weltanschauung of an intervention approach drives its methods and outcomes (Jackson, 2003). Managers who wish to act on experienced management challenges should consider their own problem context and desired weltanschauung to design an applicable intervention.

One intervention approach may not be sufficient to address a vast set of management challenges (Jackson, 2001). Methodologies exist to synthesize approaches, such as SSM, TSI, CDM, and boundary critique. These methodologies require working knowledge in the field of systems thinking. To those not educated in systems thinking, these methodologies would likely appear to be prohibitively rigorous (Jackson, 2003).

There is a need for a model to guide managers to appropriate intervention approaches without necessarily requiring systems thinking knowledge. With such a model, managers would consider how their problem context and weltanschauung match those of existing intervention approaches. From this model, an intervention approach, or combination of approaches, will be prescribed to suit the manager.

VSM, KM, and TPS have been selected as promising intervention approaches for a non-profit service organization that performs knowledge-based project work in a dynamic environment, which presents a diverse set of management challenges. These three intervention approaches each address a partial set of the mentioned challenges,
but a single intervention approach does not exist to address all of the challenges. Combining the three provides enough diversity to address the three primary management challenges in the case considered: the necessity for a non-centralized management structure, knowledge retention, and meeting diverse stakeholder demands. An ideal intervention would synthesize these to extract beneficial elements from each. This is referred to as a complementarist approach (Jackson, 2003). The three approaches have differing weltanschauungen and were developed to act in differing problem contexts. A manager acting at an organization such as the one considered here would benefit from a model to define several problem contexts and the approach to apply in each. Such a model could also advise, in a complementarist approach, how to prioritize the simultaneous application of multiple intervention approaches, thus guiding a holistic management intervention.

1.4 Research Questions

1. How are intervention approaches defined?
2. How are problem contexts defined?
3. How are intervention approaches selected for an experienced problem context?
4. How can multiple intervention approaches be applied simultaneously?

1.5 Research Purpose

Develop a framework and method that will help managers benefit from critical systems thinking without education in systems thinking. Add definition and structure to existing methodologies.

1.6 Research Objectives

1. Develop a framework for defining intervention approaches and problem contexts to be used as a tool for intervention approach selection
2. Develop a method for selecting intervention approaches for a problem context using the framework developed
3. Describe an application of framework and method in a case study

1.7 Limitations

1. The proposed framework and method were not implemented as part of this project due to time constraints.
2. Application of the proposed method assumes knowledge of intervention approaches selected.
3. Quantification of intervention approaches and problem contexts is currently based solely on expert opinion. In this research, a proper test of qualitative and quantitative methods of using the framework was not conducted.
4. Quantification of intervention approaches and problem contexts has forced characteristics based on the design of the questionnaire.
5. In its current state, the framework and methods are intended only for organizations similar to the case discussed. Adaptations and expansions of the framework and methods may be necessary for application to other types of organizations.
6. Further definition should be established to the method of deeming intervention approaches primary, secondary, tertiary, etc.

1.8 Benefits of the Study

The outcomes of this research provide the EEC with a useful tool and method to address problem contexts. Ideally, the tool and method developed will be applicable to other organizations.

1.9 Research Outputs and Outcomes

1. A framework for defining intervention approaches and problem contexts
2. A method of selecting and applying intervention approaches based on a problem context

The research is comprised of three papers, two of which have been submitted and presented at international conferences; the third will be submitted to a scholarly journal. Table 1 shows the purpose, outcomes, and relation to this research project for each of the three papers. It also shows in which chapter each paper can be found.

Table 1. Summary of Research Papers for Project

<table>
<thead>
<tr>
<th>Paper Number</th>
<th>Project Chapter Number</th>
<th>Purpose</th>
<th>Outcome</th>
<th>Relation</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>Explored the case study and selected intervention approach techniques.</td>
<td>VSM, KM, and TPS are compatible with each other and applicable to the case study.</td>
<td>Introduction to case study and intervention approaches</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>Developed a framework to define intervention approaches and problem contexts. Showed conceptual applicability of selected approaches to case study.</td>
<td>Intervention approach and problem context definition framework.</td>
<td>Research question 1, research question 2, research question 3</td>
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<tr>
<td>3</td>
<td>5</td>
<td>Developed method of quantifiably defining problem contexts and intervention approaches in the framework. Developed a method of selecting and applying intervention approaches using the framework.</td>
<td>Intervention approach selection and application method.</td>
<td>Research question 3, research question 4</td>
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Chapter 2

2 Methodology

2.1 Case Study Definition

2.1.1 Background

The Oregon State University (OSU) Energy Efficiency Center (EEC) is a student-operated organization with faculty oversight that engages in outreach to promote energy and resource efficiency. The primary project of the EEC is the Industrial Assessment Center (IAC), which exists primarily to perform industrial energy efficiency assessments. Other grants have been earned by the EEC to pursue other projects, including assessments of facilities in other sectors. Additionally, the EEC works to increase awareness of energy efficiency and provide resources for the public to self-assess energy efficiency measures (OSU Energy Efficiency Center, n.d.).

The EEC has a multi-faceted mission, which includes performing facility assessments, providing energy efficiency resources for the public, developing skills of university students, facilitating a connection between academia and industry, providing research opportunities, and generating funding flow through the university (OSU Energy Efficiency Center, n.d.). As a result, the EEC has many stakeholders, including the EEC director, faculty, and employees; assessment clients; OSU administration and some faculty; and the general public.

As a non-profit service organization that performs knowledge-based project work in a dynamic environment, the EEC presents several management challenges. These challenges include developing a non-central management structure, retaining knowledge in a rapid turnover environment, and meeting diverse stakeholder demands.
2.1.1.1 Management Structure
One recent EEC management modification has proven to be beneficial, but would likely benefit from additional guidance. The director established a management structure based on management segments of focus (SOFs). The goal was to distribute management tasks amongst many analysts, rather than all being handled by the director and graduate student operations managers as in the past. This intervention came at the time that the director began scaling back his involvement and desired to delegate tasks to others. The segment of focus (SOF) structure also provides opportunities for analysts to be more involved in EEC operations and gain management experience.

EEC management tasks were divided into several SOFs and assigned to various workers, based in existing experience, skill, or interest. Each SOF has a lead and an understudy, who supports the lead and is intended to become the next lead. Leads are not intended to do all the work associated with their SOF, but to manage the necessary tasks and ensure fulfilment of the role. This has led to management silos, where SOF leads are fixated on their role, but lack coordination with other management roles. Ambiguity in roles of authority has also occurred due to the large management variety. A persistent challenge has been designing an effective avenue for SOF leads to provide operations managers with status updates in their respective SOFs.

2.1.1.2 Knowledge Utilization
Ideally, knowledge would be accessible to employees at point of use. Many employees begin their work at the EEC with little-to-no experience in industrial energy efficiency. This creates dependence on experienced staff to train new employees on technical analyses in addition to operational policies and practices. Once employees possess the foundational knowledge and skills for energy efficiency analyses, learning is driven by experience (Levy, 1965). As analysts gain experience at the EEC, their general and specialized knowledge grows.
The work at the EEC is knowledge-based. It consists of performing technical analyses, for which skills are expected to be developed while working at the EEC. When employees depart from the organization, much knowledge may be lost with them. This knowledge was likely developed over time during their tenure as an employee (Fong & Kwok, 2009). Being a rapid turnover organization, with average employee tenure of approximately two years, the EEC would benefit from improved knowledge retention.

The EEC uses shared digital storage spaces to make electronic resources accessible to employees. There are several shared spaces, including a network drive, an online database, online applications, and websites. Looking for a particular piece of information can lead to a searching process across storage spaces. Better definition and organization of shared storage spaces would be beneficial, allowing access to appropriate resources more quickly.

2.1.1.3 Complex Operations and Diverse Stakeholder Requirements
The deliverables of facility assessments are reports prepared for client companies. A report contains information about the client company and recommendations for process improvements and cost savings, which can include reducing energy use, reducing waste, and increasing productivity. The report generation process contains many mutually dependent events, combining the efforts of several employees, whom are all college students, meaning they have limited time and attention for EEC tasks. Furthermore, employees often require assistance in completing tasks if they are not experienced. For these reasons, there is much potential for bottlenecks to occur in the report generation process. Thus operational efficiency increases are desired.

Operations at the EEC are driven by requirements of stakeholders. Funding agencies place constraints on the assessment process in terms of total number of employee hours used, time to complete reports, and quality of reports. Continuation of funding depends on delivering reports subject to the constraints of funding agencies.
Additionally, clients have expectations for assessment reports; some have special requests or needs that require accommodation. Since the reputation of the EEC and OSU depend on positive interactions with clients, delivering reports of maximum usefulness to clients is desired.

2.1.2 Selecting Applicable Intervention Approaches

Because of the need for a non-centralized management structure, retention of knowledge in a rapid turnover environment, and adhering to diverse stakeholder demands, the EEC is in need of a management intervention. A holistic management model is sought by the EEC, especially as the faculty director delegates more responsibility onto student managers. Viable system model (VSM) has been selected to provide an organizational structure with strong and effective collaboration within it. Knowledge management (KM) will facilitate improved utilization of employee knowledge, including improved organization and retention of knowledge. Toyota production system (TPS) techniques will aid in ensuring maximum value is delivered to stakeholders with minimal waste.

VSM, KM, and TPS all have contributions to improving management of the EEC, but none of them alone address the entire problem. Therefore, these intervention approaches must be synthesized, combining crucial elements of each, to create a holistic management model for the EEC and similar organizations.

2.1.2.1 Viable System Model

Efforts must be made to ensure cohesion of managers and workforce. If such considerations are not made, the “silo effect” may occur, where components of the organization are not effectively collaborating. This can have detrimental effects in organizations such as competing or conflicting objectives, organizational policy or structural breakdown, slow decision making, poor coordination in completing products, employee confusion, poor communication, poor sharing of resources, and poor training (Sy & D’Annunzio, 2005). The viable system model (VSM) frames
organizations in terms of roles and interactions, opposing the blame-based culture that may result from hierarchical organizational structures (Beer, 1984).

According to Stafford Beer, creator of VSM, organizations must consist of particular roles and interactions to ensure viability. A viable organization is one that is capable of existence independently of other entities in its environment. Organizations can exist in non-viable states, but they are at risk of failure, or at least not meeting their potential (Beer, 1984). Thus, organizations are benefitted by striving for viability.

Viability is achieved by components of an organization filling roles defined by VSM. There are five necessary components, referred to as subsystems, within VSM. Subsystem 1 consists of operational elements in an organization. This subsystem consists of the workers generating products or services for the environment. It is broken into components based on their contribution to the environment. Each subsystem 1 component has its own management unit. Subsystem 2 coordinates the operations of subsystem 1. It maintains stability and smooth operations. Subsystem 3 provides resources to subsystem 1, intervening with management of subsystem 1 components when necessary. Subsystem 3* sporadically audits the outputs of subsystem 1 to inform subsystem 3. Subsystem 4 observes the environment to help the organization react and plan for the future. Subsystem 5 is in charge of organizational policy. It represents the organization in the outside world. It also supports subsystems 3 and 4 (Beer, 1984; Vidgen, 1998). Each subsystem has a limited role to play in an organization. A breakdown in any of the subsystems will lead to non-viability of the organization. VSM is focused on control to facilitate effective collaboration, which depends heavily on communication throughout the organization (Beer, 1984). A diagram of the structure of VSM is provided in Appendix A, Figure A1.

VSM uses the law of requisite variety to guide an organization’s interaction with its environment. This law states that variety in the environment should be addressed with
variety in the organization. The goal is for an organization to possess enough variety to match the variety of its environment, meaning that it has the tools to address any threat the environment poses (Beer, 1981; Beer, 1984). This can be seen as having a plan for any scenario the environment presents. One method to boost variety within the organization is by using conferences to encourage participation (Beer, 1981). Thus, organizations benefit from using groups rather than individuals to complete tasks and fill roles, encouraging a collaborative workforce.

Creating a non-centralized management structure (management delegation) is one technique to reduce the variety in an organization’s environment (Beer, 1981). This reduces the burden of an organization boosting its own variety to match that of its environment. For example, subsystem 5 should focus its efforts on policies of the organization, allowing others fill complementary organizational roles. It should not act on the roles of any other subsystem unless a subsystem lacks sufficient variety to address a threat to the organization (Beer, 1981). A top-heavy organizational structure can threaten its own viability (Jackson, 2003).

VSM supports viability of an organization as a whole, but advises against subsystems seeking viability in their own right (Vidgen, 1998). However, VSM exhibits recursion, meaning full versions of the VSM structure are contained within every VSM structure, creating infinite levels of recursion. According to the recursive nature of the VSM, operational elements within subsystem 1 must be full viable systems within themselves. This means that each level of recursion contains a complete VSM structure within each of its subsystem 1 components, and its whole structure is within a subsystem 1 component of another VSM structure (Beer, 1984). This does not mean that subsystem 1, or any other subsystem in VSM, should attempt to be viable (Vidgen, 1998). Non-centralized management structures prevent the concentration of too many roles on too few employees in the organization, thus simultaneously boosting variety and discouraging attempts at viability over performing dedicated roles.
2.1.2.2 Knowledge Management

Drucker defines a knowledge worker as “a knowledge executive who knows how to allocate knowledge to productive use” (as cited in Nonaka and Takeuchi, 1995, p. 7). In this research, knowledge-based work is defined by work tasks completed by knowledge workers.

Direct experience is the most valuable method of learning (Nonaka & Takeuchi, 1995). Because of this, experienced workers have knowledge that is not expected of new workers (Levy, 1965). This creates a management challenge because distribution of knowledge must take place to ensure that workers can complete their tasks. Employees that can independently complete their tasks are valuable to an organization. But knowledge, and thus value to the organization, is developed over time (Davenport & Prusak, 1998; Levy, 1965). Time can be saved if knowledge is transferred, rather than having to be regenerated for each worker that requires it (Fong & Kwok, 2009). Not only must knowledge be shared amongst the workforce, but it also must be retained to be applied beyond the tenure of any member of an organization.

In this research, rapid turnover of workforce refers to when employee tenures at an organization are short. This presents challenges in sustaining a sizable workforce and utilizing the knowledge gained by employees. When a worker possesses valuable knowledge, if action is not taken to retain it, the knowledge will be lost when this person leaves the organization (Fong & Kwok, 2009). Knowledge loss has detrimental effects on the organization. One potential effect is the loss of output quality when knowledge is no longer present in an organization. Another effect is an increased burden of management to train a replacement worker, which occurs more frequently in rapid turnover environments due to a higher frequency of employee departures. Allowing new employees access to an organization’s knowledge base can aid training efforts (Nonaka & Toyama, 2003).
Knowledge management (KM) strives to make the best use of knowledge within and created by an organization to improve operations (Davenport & Prusak, 1998). It fundamentally defines knowledge in two ways: tacit and explicit. Tacit knowledge is contained within an individual and difficult for others to access. Explicit knowledge is documented and available for others to access. A primary goal of KM is to make the conversion from tacit to explicit knowledge so that it may be shared and applied. The four steps of KM can be described as 1) collection (individual tacit to group tacit), 2) retention (tacit to explicit), 3) distribution (separate explicit to systemic explicit), and 4) application (explicit to tacit) (Nonaka, 1991; Nonaka, Umemoto, & Senoo, 1996). Organizations experiencing rapid turnover of the workforce benefit from retaining and sharing knowledge by converting it from tacit to explicit knowledge before workers leave the organization.

2.1.2.3 Toyota Production System

Complexity is defined by emerging characteristics due to the structure of a system. Emergence in complex production systems can present higher risk of production problems compared to simpler systems, thus creating management challenges (Calvo & Flumerfelt, 2015; Senge, 1990). Two characteristics of operations that increase complexity are many steps in production and dependent events. Having many steps in a process is an example of detail complexity (Senge, 1990). Having more steps in a production process means there are more potential sources of error or defects. It may also mean that there are many different tasks involved in production. According to the law of requisite variety, an organization with a large variety of tasks demands a large variety of resources (Beer, 1984).

Another feature that increases complexity in operations is dependent events. When sequential tasks must be performed in series, rather than in parallel, they are dependent on each other. Dependent events represent dynamic complexity because the consequences may become apparent as time passes (Senge, 1990). A given task
cannot begin until the preceding task is complete. In this case, variability in task completion time can be detrimental (Hopp & Spearman, 2001).

Constraints are limits placed on operations. Project work often has constraints placed on it. Commonly, project constraints exist to meet quality expectations, limit costs, and limit duration to completion (Larson & Gray, 2011). These requirements are generally set by the owner of the project. The owner is in control of the project and can terminate it at any time (Checklnd, 2000). The owner is often the individual or agency funding the project.

Toyota production system (TPS), later known as lean manufacturing, was developed in the manufacturing sector and has been adapted for service organizations (Lander & Liker, 2007). The primary goal of TPS is cost reduction. There are three sub-goals necessary to achieve the primary goal; including quantity control, quality assurance, and respect for humanity. Its method to achieve these goals is eliminating waste in operations, which leads to better quality and less costly production (Monden, 1983). TPS uses several tools to identify waste and seek opportunities for improvement; however it should be viewed as a systemic approach, not simply a set of tools (Lander & Liker, 2007). It identifies four concepts for process improvement; including just-in-time production, automation, flexible workforce, and creative thinking or innovative ideas. These concepts are addressed by eight systems and methods (Monden, 1983). Some of these are more difficult to connect to low volume, high variety environments, such as service organizations, because of the roots of TPS being in high volume automobile manufacturing (Lander & Liker, 2007). The TPS methods that will be most applicable in the case considered here are reduced setup time, employee involvement and empowerment, quality at the source, equipment maintenance (not literally equipment in this case), and standard operations. These principles can help service organizations in meeting diverse stakeholder demands.
2.2 Developing Intervention Approach and Problem Context Definition Framework

2.2.1 Intervention Approach Application Literature Review

To understand the problem contexts that intervention approaches are applied in, a literature review was conducted. The intervention approaches selected were viable VSM, KM, and TPS. The literature review focused on articles where at least one of the three intervention approaches were applied, using a tool called CATWOE (described below) to define the problem contexts.

2.2.1.1 Literature Selection

Selected literature articles, containing real world applications of VSM, KM, and TPS in environments similar to the example case presented here, were gathered. Ten articles with appropriate applications were gathered for each of the three intervention approaches, for a total of 30 articles. The equal number of articles for each approach ensures equal consideration for each. Ten articles is only enough to make preliminary assessments, not enough to draw conclusions. Ten cases are few enough that each case could be examined with proper attention and demonstrates the selective nature of the literature review.

2.2.1.2 CATWOE

The six elements of the CATWOE methodology were recorded. CATWOE is a mnemonic for customer (C), actor (A), transformation (T), weltanschauung (W), owner (O), and environment (E). It is a tool of SSM to define systems of purposeful activity (Checkland, 2000). It was used here to describe applications of the three intervention approaches to real world cases. The goal was to identify similarities and differences in the approaches and their applications.

The elements of CATWOE for the EEC and for each case in the articles collected were determined. The goal was to use articles presenting cases that share
environmental (E) elements and similar stakeholders (C, A, and O) with the EEC. This demonstrated that the intervention approaches in the articles are applicable to the EEC and organizations with similar characteristics. Although the organizations described in the articles and the EEC share CATWOE characteristics, a diverse set of organizations are included. This hints that these intervention approaches are widely applicable.

2.2.1.3 Literature Analysis
Once CATWOE elements for all articles were noted, generalizations were made about each of the three intervention approaches. A key component of this was categorizing the stakeholder elements: customer (C), actor (A), and owner (O). Categories of stakeholders included company, consultant, government agency, citizens, academic institution, and researcher. Table 2 gives a basic summary of the categorization of C, A, and O. Number of Customers, Actors, and Owners is the number of these stakeholders identified in the application articles. “Most Common” is which stakeholder appeared the most in the articles considered. “Frequency of Most Common” is how many times (out of the ten total articles for each approach) the most common stakeholder appeared.

Table 2. Application Literature Summary for C, A, and O

<table>
<thead>
<tr>
<th></th>
<th>Customer</th>
<th></th>
<th></th>
<th>Owner</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of</td>
<td>Frequency of</td>
<td>Number of</td>
<td>Frequency of</td>
<td>Number of</td>
</tr>
<tr>
<td></td>
<td>Customers</td>
<td>Most Common</td>
<td>Actors</td>
<td>Most Common</td>
<td>Owners</td>
</tr>
<tr>
<td>VSM</td>
<td>5</td>
<td>5/10</td>
<td>2</td>
<td>9/10</td>
<td>3</td>
</tr>
<tr>
<td>KM</td>
<td>2</td>
<td>7/10</td>
<td>4</td>
<td>4/10</td>
<td>3</td>
</tr>
<tr>
<td>TPS</td>
<td>2</td>
<td>9/10</td>
<td>5</td>
<td>3/10</td>
<td>2</td>
</tr>
</tbody>
</table>

After analyzing stakeholders, focus was shifted to the transformation (T), weltanschauung (W), and environment (E) for each intervention approach. It was determined that Venn diagrams were the most effective way to organize and display the findings for these CATWOE elements. Figure 1 shows a Venn diagram for T.
practice, VSM, KM, and TPS are all used to diagnose problems or for auditing functions.

Figure 2 shows a Venn diagram for W. The only weltanschauung shared by VSM, KM, and TPS is responding accurately and rapidly to the environment. Three have differing methods of responding to the environment, but all value interactions with the environment. Many other weltanschauungen are shared between pairs of two of the three intervention approaches.

Figure 3 shows a Venn diagram for E. Unlike for T and W, the three intervention approaches share many environmental factors, implying that they are applied in similar cases.

Figure 1. Application Literature Transformation Venn Diagram
Figure 2. Application Literature Weltanschauung Venn Diagram

Figure 3. Application Literature Environment Venn Diagram
Based on observations regarding stakeholders (C, A, and O), and the other CATWOE elements, four categories of intervention approach definition were created.

2.2.2 Framework Structure

Similarities in stakeholders, particularly customers and owners, and environments of the applications demonstrated that these intervention approaches are applied in similar situations. The observed differences in transformations and weltanschauungen showed that these approaches have differing purposes and perspectives that should be explored. A framework was developed to define intervention approaches based on observations from the literature applications.

2.2.2.1 Four Categories

Four categories were developed to define intervention approaches. The categories are scope, inspiration, solution, and ideal. These categories each range between two extremes. Scope describes on what level of an organization intervention occurs, ranging from organizational operations to organizational design. Inspiration considers what gives meaning to the intervention, ranging from resource (internally) driven to context (environmentally) driven. Solution describes what the goal of intervention is, ranging from optimal amount of resources to right, or adequate, amount of resources. Ideal implies what the intervention approach values, ranging from organizational culture to organizational control. Intervention approaches may not be defined by either extreme. In this case, it assumed that they have either dual consideration for the extremes or indifference between the extremes.

2.2.2.2 Placing Intervention Approaches

VSM, KM, and TPS were each defined using the four categories of definition. VSM functions using the law of requisite variety, which states that an organization should contain enough variety to address the variety of its environment (Beer, 1981; Beer, 1984). It does not state that an organization should be prepared to address every possible scenario in all existing environments. It teaches that an organization should
prepare itself for the threats of the environment, and when an unanticipated threat arises, the organization should adapt using the autonomy granted throughout (Jackson, 2003). Therefore, it aims for the proper amount of resources to act in its environment, not necessarily the optimal amount of resources. VSM is primarily concerned with viability of an organization, not the specific stock of resources to achieve this. The method of achieving viability is based in the theory of organizational cybernetics, the science of effective organizations. This theory depends on organizational control (Beer, 1981). VSM proposes specific roles and interactions within an organization, and interactions between the organization and its environment, making it context driven (Beer, 1984). Thus the scope of VSM’s intervention is organizational design.

According to Monden (1983), TPS is based on reducing waste in operations. It does not heavily consider organizational design, thus its scope is generally limited to organizational operations. It is internally driven, seeking optimality in utilization of resources, with a goal of eliminating waste. TPS strives for waste elimination with the understanding that this is an unreachable goal. In this way, TPS emphasizes continuous improvement, which requires an organizational cultural shift.

KM falls close to the centre of the spectrums of all four categories. KM is motivated by both internal operations and the environment, seeking to exploit knowledge from both (Grant, 1996). It is ultimately driven to improve organizational operations, but encourages modifying organizational design to support this if necessary (Grant, 1996; Nonaka & Takeuchi, 1995). KM shares the concept of continuous improvement with TPS (Hicks, 2007; Nonaka, 1991). This implies a tendency for KM to strive for optimality in operations, rather than settling for adequate use of resources. KM depends on cultural shifts to make the most effective use of knowledge and to seek continuous improvement, including continuous innovation (Davenport & Prusak, 1998; Nonaka & Takeuchi, 1995). As a result, it is expected that the effective
utilization of knowledge will spread throughout the organization. This implies an interest in organizational control in addition to organizational culture.

2.2.2.3 Beneficiary Line
Upon definition of VSM, KM, and TPS in terms of the four categories developed, it was noted that, when applied in organizations, these benefit different stakeholders. The two categories of beneficiaries are workers and management. TPS primarily benefits workers by empowering them and providing support in operational settings (Monden, 1983). VSM primarily benefits management as it considers the functioning of the organization as a whole, not considered with how subsystem 1 workers do their work (Jackson, 2003). Primarily worker benefiting interventions focus on supporting workers and improving the work they do. Primarily management benefiting interventions act in the organization on a larger scale, which does not consider the workers directly, but control over the work they do.

The resulting framework is shown in Figure 4.
2.3 Developing Intervention Approach Selection and Application Method

2.3.1 Existing Methodology Review

When a single intervention approach is insufficient to address all management problems, more holistic intervention is necessary. This type of intervention combines several intervention approaches completely (i.e. pluralist approach) or utilizing components of each (i.e. complementarist approach). A method is needed to guide practitioners in applying intervention approaches selected using the framework. Several methodologies exist for combining many perspectives, which is equated to combining approaches because each approach has a different perspective. These methodologies were reviewed to inspire the proposed framework and method.
2.3.1.1 Soft Systems Methodology

Soft Systems Methodology (SSM) was developed by Peter Checkland, who noticed that management science at the time was predominately based on ‘hard systems thinking’, structuring real-world scenarios as optimization problems based on goal-seeking. SSM is intended for use in complex scenarios lacking definition in structure and objective, where relationships of stakeholders are highly valued. This made it highly applicable to human activity systems, where people act to contribute to a purpose, such as organizations. In SSM such systems are viewed as loosely structured and dynamic with many perspectives to consider (Jackson, 2003). Figure 5 is a conceptual model of the SSM process.

![Figure 5. Soft Systems Methodology Diagram (Checkland, 2000)](image)

2.3.1.2 System of Systems Methodologies

Jackson (2003) developed a framework for defining applied systems thinking strands, called the system of systems methodologies (SOSM). This framework describes problem contexts based on systemic complexity (the vertical axis) and the collaborative relationship between participants (the horizontal axis). Strands of applied systems thinking are defined in terms of problem contexts for which they are applied, based on the complexity and participant relationship. Systemic complexity ranges from simple to complex. Complexity is driven by quantity of subsystems, and quantity and structure of interactions. Simple systems have few subsystems, and contain few and highly structured interactions. On the other hand, highly complex systems have many subsystems, and contain many loosely
structured interactions. Additionally, simple systems are fairly static over time, whereas highly complex systems transform over time according to changes in their own parts and their dynamic environment (Jackson, 2003).

There are three types of participant relationships: unitary, pluralist, and coercive. A unitary relationship exists when participants share values, beliefs, and interests. Participants in a pluralist relationship will share interests, but have differing values and beliefs. Decision making in pluralist contexts depends on disagreement and conflict, leading to constructive debates. Compromise is attainable, even when all participants are active in decision making. Coercive participants will have varying interests and will not share values and beliefs. In coercive contexts, power is exercised to make decisions and compromise does not exist (Jackson, 2003).

Jackson (2003) later mapped applied systems thinking approaches on the SOSM. This modified model is valuable to show the assumptions made by systems approaches regarding problem contexts. The SOSM model with systems approaches is provided in Figure 3. According to the SOSM, the research being presented here is focused in the highlighted regions of Figure 6. This includes all pluralist problem contexts, and complex unitary contexts. Therefore, the systems approaches considered here are primarily soft systems approaches, which are commonly human systems such as organizations, and organizational cybernetics.
2.3.1.3 Total Systems Intervention

Critical systems thinking (CST) is an adaption of systems thinking, intended to address complex problems with multiple differing viewpoints. These are the types of problems experienced in many organizations and other human systems. Total systems intervention (TSI) was developed as a methodology for applying CST in scenarios such as organizational management (Jackson, 2003).

Methodologies have strengths and weaknesses that can complement each other. They also have differing weltanschauungen, providing different perspectives of the problem context. TSI intends to make use of multiple systemic methodologies to address situations where a variety of perspectives are necessary for a holistic view. It aims to guide facilitators and participants to agreement about the major issues faced. Based on this agreement, systems methodologies are selected for intervention, with their strengths and weaknesses considered. The selected methodologies should be used in combination for intervention in corresponding aspects and contexts of organizations. It encourages constant reflection on the methodologies selected, as they may need reconsidering as the situation changes (Jackson, 2003).

Figure 6. System of Systems Methodologies with Areas of Interest Highlighted
(based on Jackson, 2003)
The TSI methodology has three phases: creativity, choice, and implementation. The creativity phase is intended to reveal the primary concerns, issues, and problems in the situation. It is crucial that several viewpoints are used to achieve the outcome in this stage. The choice phase is when the intervention strategy is developed. Knowledge and information gained in the creativity phase, along with the strengths and weaknesses of methodologies considered, are used to determine a dominant and some dependent methodologies to be used for intervention. The final phase is implementation. At this point, the dominant methodology chosen will be used primarily to address the situation. Benefits offered by other methodologies should always be considered. Actors should repeatedly revisit the three phase cycle of TSI. It is especially important to constantly question the choice of the dominant methodology and adjust this choice if necessary. This will be absolutely necessary if the problem situation changes (Jackson, 2003).

One weakness of TSI, as explained by Jackson (2003), is its commitment to pluralism, meaning it requires the use of methodologies as “wholes”. TSI requires that the dominant methodology be implemented as a whole, possibly blocking out dependent methodologies where the dominant methodology acts.

The usability of TSI has also been critiqued. Lack of instruction for navigating the three phases, especially creativity and choice, has been the source of some criticism. There have also been concerns surrounding the inconsistency of TSI with regards to its acceptance or rejection of alternate approaches. Others have claimed that TSI ignores environmental factors while focusing on considering perspectives of many stakeholders (Jackson, 2003).

TSI was developed to facilitate the use of multiple systemic methodologies (i.e., methodologies in the realm of systems thinking) to address complex problem contexts. However, methodologies that are not “systemic”, or in the field of systems thinking, may have much to offer certain problem contexts.
2.3.1.4 Creative Design of Methods
Midgley (as cited in Midgley, Munlo, & Brown, 1998, p. 306) developed a concept called creative design of methods (CDM) based on the TSI concept that simply choosing a single methodology for intervention may be insufficient in complex problem contexts. As Jackson (2003) explained with regards to TSI, a variety of perspectives are necessary for a holistic view of complex problem situations.

Midgley, Munlo, and Brown (1998) emphasized that CDM synthesizes multiple methodologies to create a single intervention method. It combines methodologies to create a new method that is more valuable than the individual methodologies in the problem context. TSI encourages the use of methodologies in their complete and pure form with dominant and dependent methodologies identified. CDM uses pieces of methodologies as they apply to the problem context to create a custom intervention method.

Generation of a CDM intervention method is driven by a series of systematically interrelated research questions developed based on the desired outcome. Boyd et al. (2007) noted that the purpose of intervention, which drives the research questions, may change as the analysis develops. A methodology to address each of the research questions is chosen. The selected methodologies are synthesized to create an appropriate intervention method. The means of developing these research questions and designing the resulting method is not well defined, but Midgley, Munlo, and Brown (1998) stated that intuition and deliberation may be tools used for decision making.

2.3.1.5 Boundary Critique
Boundary critique was developed by the work of Ulrich and Midgley, based on previous work by Churchman. It is a discipline of critical systems thinking which explores alternate boundaries of analysis and how adjusting the boundaries affects intervention, while maintaining critical awareness. Critical awareness means
constantly considering assumptions and their basis (Midgley, Munlo, & Brown, 1998).

Churchman (as cited in Midgley, Munlo, & Brown, 1998, p. 467-468) determined that the boundary of a system under analysis is an important consideration. He expresses that boundaries are created, not given. He believes that wider boundaries may deem some improvements insignificant; therefore, he encourages definitions of improvement which contain as much information as possible. Churchman supports widening of boundaries, including several differing perspectives, referred to as ‘rolling out’ the boundaries. Widening of boundaries may affect who is considered a decision maker. He asserts that practitioners should consider the perspectives of the strongest possible enemies. Improvement attempts should only be continued if robust arguments against enemies exist.

Ulrich (as cited in Midgley, Munlo, & Brown, 1998, p. 468) created a methodology called critical systems heuristics to appropriately select boundaries using stakeholder collaboration. Ulrich believes that Churchman’s desire to include as much information as possible into improvement definitions is limited by the need for practical solutions. Ulrich maintains that all assumptions should be subject to questioning. To ensure improvements are ethically sound, Ulrich explains that an agreement must be met between the designers and those affected by proposed actions.

Midgley (as cited in Midgley, Munlo, & Brown, 1998, p. 469) examined situations where stakeholders disagree about the boundaries of a system. When conflicting boundary definitions exist, one is narrower and one is wider, these are assigned as the primary and secondary boundaries, respectively. The area in between the defined boundaries, included in the secondary boundary but not in the primary boundary, is said to be marginalized. To resolve boundary conflicts, the marginalized area is deemed either sacred or profane. When the marginalized area is profane, the primary boundary is given priority in decision making. This means that the marginalized area
and secondary boundary are not considered. When the marginalized area is sacred, everything within the secondary boundary, including the marginalized area, is considered in decision making. However, Midgley emphasized that those making boundary judgements must not neglect what is contained in the marginalized region when a profane status is imposed. Figure 7 illustrates a marginalized region between a primary and secondary boundary.

![Figure 7. Model of Marginalization in Boundary Critique (Midgley, Munlo, & Brown, 1998)](image)

In practice, boundary critique is executed in two phases. Phase 1 is Identifying Problems. In this phase, stakeholders are identified to be interviewed. One technique to develop the richest understanding of the problem context is starting with stakeholders that are easy to identify, then asking them to name others that should be interviewed. This was developed by Midgley and Milne (as cited in Midgley, Munlo, & Brown, 1998, p. 471) to ‘roll out’ the boundaries of analysis. After Phase 1, it is beneficial to review the work done to ensure that marginalized entities are not being treated as profane prematurely. To prepare for Phase 2, Designing Improvements, a workshop is held to develop an intervention plan with key stakeholders within the relevant boundary. To guide intervention, stakeholders are encouraged to imagine an ideal scenario, ‘ideal’ meaning ‘best possible’ but reasonable technologically and
organizationally. Midgley, Munlo, and Brown (1998) described a case study in which the problem solving team devised a plan to synthesize three methodologies to approach the ideal state.

2.3.2 Quantification

To ensure accuracy and consistency of intervention approach and problem context definition in the proposed framework, a quantitative method is necessary. Expert opinion is the driver of quantification in the proposed method.

2.3.2.1 Preliminary Approximations

Qualitative approximations about the placement of VSM, KM, and TPS were made preliminarily. This process is further discussed in section 2.2.2.2. Figure 8 shows where these approaches were expected to be located on the proposed framework.
Figure 8. Intervention Definition and Application Framework with VSM, KM, and TPS

2.3.2.2 Axis Scales
A practitioner will have to analyze the experienced problem context in each of the four categories previously discussed: Scope, Inspiration, Solution, and Ideal. Each of these categories has a scale ranging between two extremes. To make the analysis quantifiably-based, two-directional 0 to 5 scales are displayed on each of the four axes. This is shown on the framework in Figure 6. Zero is at the center of each axis, representing a neutral position. Each axis has two 5 values, one for each extreme on a given axis. During the following analysis, each “extreme” of each axis will be assigned a number ranging from 0 to 5, representing how strongly valued the “extreme” is in the problem context. The strongest value for an “extreme” is expressed by assigning a 5. Conversely, assigning a 0 to an “extreme” demonstrates minimal value in the problem context.
2.3.2.3 Quantification Questionnaire

A quantification questionnaire is used to capture the value of each “extreme” for each axis. The questionnaire contains a scale for each of the four categories. For each category a numbered scale of 0 to 5 in two directions is provided. On the scale is a shaded box with a length of five units on the scale. This shaded box represents the area of value on the scale. A practitioner moves the shaded box toward one extreme or the other to demonstrate preference of one over the other, and the strength of that preference. The scale numbers on each edge of the shaded box are the values assigned to the associated extreme. The strongest expression of preference is shown by the box placed all the way to one extreme, thus assigning a value of 5 to one extreme and 0 to the opposite extreme.

Research questions may aid the practitioner in assigning values in each of the four categories. This concept is borrowed from CDM, where research questions are used to establish the purpose of intervention, and thus guiding the selection of intervention approaches. These questions may also add clarity to what each category, and the associated extremes, entails. Research questions for each category are provided below.

Scope

• Is the problem context an issue of generating work products (i.e., operations), or is it a consequence of organizational structure (i.e., design)?

Inspiration

• Is the problem context primarily concerning organizational resources, or does it involve the external environment (i.e., context)?

Solution

• In the problem context, is it necessary to seek a specific goal (i.e., optimize) with one correct solution, or can it be satisfied with an adequate solution? (An
adequate solution implies that there are multiple correct answers or that the goal is not well defined.)

Ideal
- Will the problem context be most affected by shifts in organizational culture, or modifications in organizational control?

A model of the quantification questionnaire is provided in Figure 9. The shaded box positions shown are arbitrary, placed to demonstrate the most neutrality possible in each category.

Figure 9. Quantification Questionnaire Model
It should be noted that the questionnaire design forces certain outcomes to occur. Firstly, the sum of the values assigned to each extreme is five for each category. This was a design decision for the preliminary method. It forces equal weighting for each category. More flexibility in rating the four categories for problem contexts and intervention approaches would increase the accuracy and usability of the proposed framework and method. In the future, managers may wish to consider some categories more heavily than others. Some categories may not even be relevant to certain problem contexts. Furthermore, intervention approaches do not consider all four categories equally due to their differing weltanschauungen. If a category is not relevant or not desired for the problem context or intervention approach, the length of the shaded box could be expanded, up to ten units. If a category is to be weighted heavily, the length of the shaded box should be reduced, showing more precision in the decision. The challenge this presents is that theoretically, this would result in assigning a negative value to the “extreme” that is less desirable. This is a challenge that will have to be addressed in future expansions on this research.

Another consequence of this design is that the practitioner must express preference for one of the two extremes in each category. This is due to the selection of a maximum value that is an odd number. Even the most neutral result, 2 and 3 or 3 and 2, shows a slight preference for one extreme. This allows practitioners to have dual consideration between extremes if desired, but forces determination of a preference.

After each “extreme” is assigned a value, the problem context may be defined within the framework. Use of the shaded box with a length of five units ensures that, once mapped on the framework, a problem context will be represented by a four-sided shape with all sides having length of five units.

2.3.2.4 Selecting Intervention Approaches
The shape defining the problem context in the framework will intersect at least one shape representing an intervention approach. Whichever intervention approach shape
shares the most area with the problem context shape will be chosen as the dominant, or primary, intervention approach.

If the problem context shape intersects multiple intervention approach shapes, dependent approaches may be identified to complement the dominant approach. Having selected the approach with the greatest shared space with the problem context as dominant (primary), the secondary approach will be the one with the second largest shared space. The intervention approach shape that shares the third largest space with the problem context shape will be the tertiary approach.

Given the range of values on the framework axes and the forced size of the problem context shapes, at least one intervention approach shape will be intersected. This ensures that at least one intervention approach is identified for any problem context. Although multiple approaches are likely necessary to holistically act in complex problem contexts (Jackson, 2003).

The method described so far in this section assumes that the practitioner has not already selected intervention approaches to apply. In this case, the framework will likely be able to prescribe approaches that best match the problem context. However, practitioners may have a predetermined intervention approach, or set of approaches, that are desired. This is true in the case study provided on the following pages. When intervention approaches are already selected, the framework is beneficial to establish the order of dominant and dependent approaches, including assigning dependent approaches as secondary and tertiary. When a problem context is mapped on the framework, it may not intersect at all with a pre-selected intervention approach on the framework. This likely means that the intervention approach was not designed for similar problem contexts similar to the one experienced, but it may still have beneficial elements. It would likely not be beneficial to assign dominant status to an intervention approach that does not overlap the problem context. Instead, the method described above for assigning dominant and dependent approaches should be used,
with intervention approaches that do not overlap the problem context given the lowest ranking. The approach that is closest to the problem context should be assigned higher priority compared to one that is farther away.

### 2.3.3 Applying Intervention Approaches

The final stage of both TSI and the method proposed here is implementation. The proposed method is similar at this point to the implementation phase of TSI. As Jackson (2003) has suggested, many consider this to be the best-defined phase of TSI.

Consistent with the third phase of TSI, implementation of the proposed method will give highest priority to the dominant approach while utilizing beneficial elements of dependent approaches. When considering an action in the problem context, intervention designers should first consider how the dominant intervention approach views the situation. In this way, the weltanschauung of the dominant approach will have the most leverage in the intervention. If the dominant approach does not consider, or is indifferent toward, the action considered, the secondary approach should be consulted for guidance. Furthermore, if the secondary approach is not able to guide intervention, the tertiary approach should be applied. In this way, intervention is driven by the primary approach, while utilizing beneficial elements of the secondary and tertiary approaches.

When seeking guidance from intervention approaches in pairwise fashion, the theories of boundary critique are applicable. To keep the language consistent from the earlier discussion of boundary critique, consider two intervention approaches, primary and secondary, each with its own weltanschauung. Each intervention approach has a boundary for its theory, determined by its weltanschauung. Since these two approaches do not agree on a single boundary, there is a marginalized space. The marginalized space will, by default, be considered profane. When the primary boundary is not wide enough to serve the desires of the practitioner in the problem context, the boundary must be expanded. This is achieved by deeming the
marginalized space sacred, widening the boundary of analysis to that of the secondary approach. This allows the secondary approach to guide actions that exist in the marginalized space. The same holds true when considering the secondary and tertiary approaches, if this is appropriate for the problem context.

As TSI teaches, it is important to remain critical of intervention approaches selected, especially the dominant approach. As action is taken in the real world, the problem context shift and the proposed analysis method should be reiterated. This is also true if the practitioner desires to act in a new problem context. A different set of intervention approaches may be necessary for a modified or new problem context.

2.4 Describing the Framework and Method in the Case Study

2.4.1 Defining Selected Intervention Approaches

All three intervention approaches (VSM, KM, and TPS) address part of the set of management challenges faced at the EEC. However, no single approach will address the whole set of challenges. Therefore, a complementarist approach is desired. The proposed framework is well suited to guide interventions in problem contexts encountered at the EEC. As problem contexts arise, managers can use the proposed framework and method to guide intervention actions. In this case VSM, KM, and TPS will be the set of pre-selected intervention approaches; therefore the decision is which is primary, secondary, and tertiary in different contexts.

To prepare for application, the three selected intervention approaches were mapped on the proposed framework. The method used to map the intervention approaches is identical to the method described earlier. The difference was that an intervention approach was being defined, rather than a problem context. The values assigned to all extremes are provided in Table 3.
Table 3. Summary of Quantification Questionnaire for Case Study Intervention

**Approach Definition**

<table>
<thead>
<tr>
<th>Scope</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organizational Operations</td>
<td>VSM</td>
<td></td>
<td>KM</td>
<td></td>
<td>TPS</td>
<td></td>
</tr>
<tr>
<td>Organizational Design</td>
<td>TPS</td>
<td>KM</td>
<td></td>
<td>VSM</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Inspiration**

| Resource (Internally) Driven | VSM |   | KM/TPS |
| Context (Externally) Driven | KM/TPS | VSM |

**Solution**

| Optimal Amount of Resources | VSM | KM/TPS |
| Right/ Adequate Amount of Resources | KM/TPS | VSM |

**Ideal**

| Organizational Culture | VSM | KM | TPS |
| Organizational Control | TPS | KM | VSM |

Definition of VSM, KM, and TPS as regions on the proposed framework is shown in Figure 10.
2.4.2 Example of an Intervention in the Case Study

Figure 11 represents a case where VSM is selected as the dominant, or primary, approach. Therefore, KM and TPS are dependent approaches. VSM, being the dominant approach provides the organizational structure. VSM does not define communication channels within the organization or with the environment; it only states that they are vital (Beer, 1984). KM can support these communication channels. Additionally, operational elements of the subsystems within VSM are not defined other than descriptions of their roles and interactions. There are no guidelines or tools for these subsystems to effectively operate. TPS can aim in ensuring that these subsystems are achieving their goals efficiently.

The complementarist intervention model described by Figure 11 would likely represent a case where the problem context is defined in the framework in the lower, right corner, where VSM is most applicable. Such a problem context may be defined by the question: how should the organization be designed to best allocate resources to
respond to differing client demands? According to the intervention presented, VSM would be used to ensure that all roles to ensure viability of the organization are functioning. VSM would also guide the organization to ensuring that it contains enough variety to address the needs of clients. TPS would limit the variety to a level that is not excessive or wasteful. A tool of TPS that could be used in the interaction between operational (system 1) elements of the organization and the environment is creating standard work procedures. A standard procedure for every possible situation is not necessary. Only work procedures for relevant environmental situations are needed. KM could be used to collect information from the environment to determine which work procedures are needed to act in the environment. Furthermore, KM would be used to communicate the designed work procedures throughout the organization.

Other concepts of TPS that could be applied in such an intervention are just-in-time and flexible workforce. Just-in-time would guide operational elements in timely delivery of deliverables depending on the time required for each task and the due date. A flexible workforce ensures less dependence on particular workers, allowing resources to be allocated as needed to meet deadlines. KM would help distribute the knowledge about performing certain tasks, including standard work procedures, allowing a more flexible workforce.

Without KM and TPS, VSM may have seemed like an incomplete intervention approach. Synthesizing all three creates a holistic approach to address the set of management challenges at the EEC.
Figure 11. Case Study Intervention Design with VSM as Dominant
CHAPTER 3

3 Refereed Conference Paper 1

The following chapter has been published in the proceedings of the American Society for Engineering Management (ASEM) 2014 International Annual Conference under the title “Sustainable Management Structure for Dynamic Non-profit Organizations: Integrating Lean Thinking and Knowledge Management through Systems Thinking.”

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SUSTAINABLE MANAGEMENT STRUCTURE FOR DYNAMIC NON-PROFIT ORGANIZATIONS: INTEGRATING LEAN THINKING AND KNOWLEDGE MANAGEMENT THROUGH SYSTEMS THINKING

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Abstract
A student-operated energy efficiency center presents a challenge and an opportunity for application of engineering management principles. The Oregon State Energy Efficiency Center (OSU EEC) is an organization of students that perform energy, resource utilization, and productivity assessments throughout the northwestern United States. The OSU EEC creates value for all its stakeholders in its operations. These stakeholders include clients, student-employees, Oregon State University, funding agencies, and the community. The OSU EEC operates under operational constraints, has high student-employee turnover rates, and is experiencing tightening budgets. These factors have made it imperative that this organization improve its own processes. Systems thinking, specifically soft systems methodology will be used to synthesize lean thinking and knowledge management. The combination of these theories will yield a management structure for the OSU EEC and similar dynamic non-profit organizations.

Keywords
Engineering, Systems Thinking, Industrial Engineering, Management, Knowledge Management, Lean, Sustainable, Energy, Efficiency, Resource, Productivity

Introduction
Many organizations experience rapid workforce turnover. Rapid turnover occurs when the members of a workforce change frequently. This is a consequence of employees leaving an organization after short tenures. This characteristic creates challenges for management, but can be used advantageously.

Rapid turnover can place stress on organizational learning due to lack of knowledge retention (Stata, 1989). Members of an organization typically improve their skills and increase performance as experience is gained (Levy, 1965). An experienced employee may have filled many different roles within the organization. These experiences may provide many different perspectives of the organization that contribute to knowledge growth. This makes a member more valuable because they are fully immersed in the organization. Thus their value to the organization increases with time. Then when the experienced employee leaves, a new hire will be trained to fill a gap in the organizational structure. Although the departed employee can generally be replaced by another experienced employee or a qualified new hire, the loss of knowledge is generally a concerning issue (Fong & Kwok, 2009). Ideally, the knowledge of the departing employee can be effectively retained and passed throughout the organization.

The frequent shifting of a workforce creates an environment where new talent is frequently entering the organization. This knowledge brought in by these new hires will contribute to the organization’s knowledge base (Grant, 1996). The shifting of the workforce creates change within the organization. This change is a form of fluctuation. Organizational fluctuations are essentially breakdowns that can result in knowledge development (Nonaka, Umemoto, & Senoo, 1996). The knowledge of current and
departed employees, if it is retained, can be used to train new employees. Increasing employee training will allow higher beginning work efficiency, quicker adaptation to the work, or both (Levy, 1965).

**Background**

The Oregon State University Energy Efficiency Center (OSU EEC) is an organization of students developing sustainability analysis techniques, while serving facilities throughout the northwestern United States by performing energy, resource utilization, and productivity assessments. The OSU EEC consists of undergraduate and graduate students from various disciplines of engineering. An outline of the organizational structure of the OSU EEC is provided in Exhibit A1 in Appendix A.

The OSU EEC is primarily engaged in industrial assessments, but creates value for stakeholders in several other ways. Value is defined as a benefit, tangible or intangible, realized by an entity due to its own actions of the actions of its affiliates. The stakeholders include clients, student-employees, Oregon State University (OSU), funding agencies, and the community. Clients receive value in recommendations for process improvement, students gain value in conducting analyses that complement their academic coursework, OSU benefits from the outreach and networking from the facility assessments and revenue from funding agencies, the OSU EEC helps its funding agencies in their missions and by spreading awareness, and the community benefits by the assessment resources that the OSU EEC provides for use by the general public.

The assessment and report preparation process is complex, consisting of inter-dependent events with high variability. There is a particular sequence of events that must occur between a client identification and delivery of the final report. The steps in this process are performed by members of a team, generally made up of four to five analysts. This process frequently undergoes changes. Management makes decisions without formal or consistent holistic analyses. This may lead to changes being enacted based on perception of benefits without consideration of all consequences. When changes are enacted without a holistic view, unanticipated consequences may result (Anderson & Johnson, 1997). A more holistic view of the organization would assist in more effective decision-making. Systems thinking (ST) is the practice of analyzing systems holistically and systemically (Anderson & Johnson, 1997). ST is used to define and analyze systems. For this reason it can be a strong decision-making tool. As a science, ST recognizes that systems tend to exhibit patterns, exposing similar characteristics even in differing contexts (Anderson & Johnson, 1997).

The entire assessment process, from facility visit to report mailing, is subject to constraints in time, budget, and quality. Historically, at least one of these measures must be compromised to enhance the others. In the past, the OSU EEC has delivered high quality reports, but often goes over budget and over time. Lean thinking (LT), here referring to what was originally referred to as Toyota Production System, can be used to help the OSU EEC maximize the value it delivers to its stakeholders. Increasing value often means reducing waste in the process (Womack & Jones, 1996). However, if value is based on minimizing errors, reliability, and flexibility, it may be necessary to add to the process (Landau, 1969). Coupling LT with ST can help organizations deliver high-quality products subject to the constraints placed on it (Oppenheim, Murman, & Secor, 2011).

The students in this organization have highly varying schedules and generally have a less than two year tenure. Thus the OSU EEC is a rapid turnover organization. This creates a need for retention of knowledge beyond the presence of the analysts. Knowledge management (KM) will assist this organization in the retention of knowledge. KM systems generally consist of these components knowledge creation, storage and retrieval, transfer, and application (Alavi & Liedner, 2001; Griffith et al., 2013). Ultimately, KM will enhance learning and innovation of the organization (Stata, 1989).

**Literature Review**

The following literature review encompasses these topics: ST, KM, and LT, with sub-topics in each. Specific applications of ST include Soft Systems Methodology (SSM) and the The Viable System Model (VSM). As an extension of KM, learning of individuals is discussed. Because of their
relationship to LT, organizational reliability and redundancy, and manufacturing practices in service industry are discussed. After ST, KM, LT, and the respective sub-topics are discussed, the literature combining ST, KM, and LT are addressed. Specifically, the following interactions are discussed: ST and KM, ST and LT, and KM and LT. Exhibit 1 shows a diagram of the structure of this literature review.

**Exhibit 1. Literature Review section structure.**

1.1 Systems Thinking

Michael Jackson (1983) witnessed and analyzed female initiation rites of the Kuranko tribe in northern Sierra Leone. Upon observation, Jackson became fascinated with why these rituals existed and what they meant. Jackson realized that these rituals may not be able to be explained verbally, but they hold some deeper meaning that can only be communicated by experience. Thus Jackson explored how the rituals describe their own meaning and why they are practiced. He identified that the actions of the rituals may not be deliberate or purposeful, but are an innate expression of culture. Jackson realized that physical actions and interactions can lead to development of new ideas and new experiences. The rituals provided an environment of chaos from which individual members emerged with a greater understanding of their own personality and potentially an altered personality. Mimesis is a tool for aligning differing views. Jackson asserted that social and intellectual developments are dependent on bodily self-mastery. Pretense can dampen learning that would be gained from experience. Participation can be enlightening, rather than simply being used to achieve some later objective. From these observations, Jackson developed critical systems thinking.

Jackson (2001) presented critical systems thinking as an essential element of management science in the future. Critical systems thinking is characterized by no presumptions, no universal solutions, holistic methods, combination of theory and practice, and identification and consideration of beneficiaries. Critical systems thinking combines social theory and ST, drawing on benefits from both.

1.1.1 Soft Systems Methodology. Peter Chackland (1985a) described the application of his SSM to a manufacturing company. A model of SSM as a learning system is provided in Exhibit 2. SSM is a form of action research, meaning it links theory and practice through its sequential and iterative approach. Contrary to systems engineering methodology, SSM is not goal-seeking. It places emphasis on learning and allows development of a future state as the steps are completed. SSM was originally developed to analyze complex systems, such as those of organizational management. SSM is effective at analyzing systems that include human activities. Human activities must be viewed from a particular perspective, or weltanschauung. A crucial component of SSM is considering several weltanschauungen and comparing them to identify desirable and feasible changes. SSM begins by defining the current state of the system. This requires knowledge sharing and involvement of those doing the work.
Definition of the system requires consideration of its structure and processes. The relationship between the two is considered the situational climate. Upon analyzing the climate, necessary roles emerge, the norms in those roles are understood, and the values used for evaluation of performance are identified. This process allows the unloading of tacit knowledge and may result in new thoughts even for those very experienced in the analyzed system. Operations are described in SSM in the following manner. Wealth generating operations require a support system, creating a link between operations and support. These elements operate within a particular environment. Root definitions are formed for the systems (and subsystems) under analysis. Proper root definitions are creating using the customers, actors, transformation process, weltanschauung, owners, and environmental constraints (CATWOE) framework. Root definitions developed through the SSM process should be compared to the real world state of the system.

**Exhibit 2.** SSM as a learning system (Checkland, 1985a).

Checkland (1985b) stated that studying human systems is more complicated than understanding the rules governing these systems. He introduced a process of inquiry, where theory and practice feed each other in a perpetual feedback loop. This approach was intended to be applied to management science, which is constantly evolving over time.

Checkland (2000) sought to create a method of analyzing 'management' problems, which are characterized by high complexity. His approach was to develop a mutual dependence of ideas and practice. This article provides a review of the development of soft systems thinking (SST) and explains the updated perspective that has developed since the 1970s. Exhibit 3 provides a representation of the SSM as a learning process.

**Exhibit 3.** SSM as a learning system (Checkland, 2000).
1.1.2 The Viable System Model. Stafford Beer (1984) developed a model for viable systems, which are capable of independent existence, called The Viable System Model (VSM). Beer asserted that a viable system is contained within another viable system and also contains viable systems. There are five essential subsystems in the VSM. The full model of the VSM is provided in Exhibit A2 in Appendix A. Subsystem One consists of the operational, or front line, systems which contain iterations of viable systems within themselves. Subsystem Two is the regulatory system. These systems are responsible for ensuring stability of the operational and management systems. The remaining three subsystems take on management roles. Subsystem Three is responsible for managing internal and immediate operations, including auditing the operational subsystems. Subsystem Four is strategic, managing the external environment and planning. Subsystem Five handles organizational policy, primarily concerned with regulating Subsystems Three and Four. Beer explained that a breakdown in any of these subsystems leads to system inadequacy. He also asserted that existence does not equate to viability; systems can survive being non-viable. The VSM has a hierarchical natural, but Beer claimed that strictly hierarchical organizations are not effective and mostly concerned with placing blame. An important characteristic of a viable system is the passing of information throughout.

1.2 Knowledge Management

Robert M. Grant (1996) explored the methods used by organizations to integrate the knowledge of those within it. He maintained that knowledge is contained in individuals, and individuals are instrumental in knowledge creation. He assumed that organizations primarily apply knowledge as opposed to creating it. Managers are responsible for facilitating knowledge integration. Grant provided discussion of the resource-based and knowledge-based view of firms with the premise of the latter being superior for contemporary management. Grant emphasized the importance of knowledge transferability within a firm. He proposed using tacit knowledge to know how, and using explicit knowledge for knowing about facts and theories. Knowledge aggregation refers to a growing knowledge base and leads to improved knowledge transfer. A common language for knowledge can facilitate its aggregation. When multiple types of knowledge are considered, complications arise in terms of organizational structure and decision-making. Grant identified that most knowledge is firm specific. He also claimed that individuals must specialize to be experts and those with a wide variety of knowledge are generally not experts. He argued that all social organizations face strife due to differing goals of members.

Alavi and Leidner (2001) emphasized using knowledge-based assets to create a competitive advantage by applying knowledge in an organization to create new knowledge. Knowledge can take many forms and can be contained in many ways. Thus various KM techniques are necessary in any organization. The four components of KM are: knowledge creation, knowledge storage and retrieval, knowledge transfer, and knowledge application. KM must be a constant and ongoing practice to be effective.

Fong and Kwok (2009) studied construction contracting firms to understand their use of knowledge flow and KM. Construction is a project-based industry, where employees may leave without sharing knowledge. The authors were concerned with two levels of KM implementation: project and parent. Four organizational culture types are identified. The most common type of culture for firms that use KM is clan culture, which is characterized by a common respect for human needs and relationships. The authors found that equal, complimentary levels of codification and personalization are desirable for successful knowledge flow for both level of the organization. Codification is adapting knowledge for a wide audience; personalization is transferring knowledge between individuals. Another finding was that management support is important for the success of KM systems. KM is valuable across current and projects and between projects at different points in time by reducing the redundancy of knowledge generation through the sharing of information. It was determined that face-to-face knowledge transfer was preferred by industry practitioners.

Griffith et al. (2013) examined nine award-winning healthcare organizations (HCOs). The authors found that all nine HCOs mentioned specific KM activities as part of their operations. The authors believed that the award-winning HCOs have successfully implemented and effectively maintained KM
systems to provide resources for the employees. These KM systems incorporate organizational culture with procedures. Characteristics of these KM systems are accessibility, frequent updates, and accuracy and distribution of information. This article served as a testimony that KM systems provide value in organizations, especially service organizations such as hospitals. KM incorporates evaluation, effectiveness, and continuous improvement of information in addition to storage and use of information. Critical components of KM systems are knowledge creation, knowledge application, knowledge storage and retrieval, and knowledge transfer.

1.2.1 Learning. Ferdinand K. Levy (1965) used mathematical models to demonstrate learning capabilities of individuals. In manufacturing, the number of hours to produce one unit has a negative relationship to experience of employees. Levy defined three classes of firm learning: planned or induced learning, random or exogenous learning, and autonomous learning. Planned or induced learning manifests in the learning resulting from attempts to increase productivity or reduce costs. As firms invest more in employees’ selection and training, initial efficiency is increased and the rate of learning is reduced. Random or exogenous learning result from information gathered from the external environment. Learning by experience, from repetition and mistakes, is referred to as autonomous learning. Autonomous learning applies to groups as well as individuals. When groups gain experience working together, productivity may be increased. Organizations generally reach a point of diminishing returns as training increases.

1.3 Lean Thinking
Womack and Jones (1996), co-authors of The Machine That Changed the World with Daniel Ross, were instrumental in the spread of lean manufacturing. Since the book, they have noticed that most managers are claiming to be becoming lean. However, they have identified that most of these claims are misleading. The managers who claim to improving leanness have spotty or incomplete lean implementation in their organizations. The authors introduced a framework to aid companies with implementation called LT. The authors present five steps to adopting LT: define value, identify value streams and eliminate waste, create flow in value-adding steps, supply customers accurately and just in time, and constantly improve.

Bowen and Youngdahl (1998) explained that in the past, the general view was that manufacturing principles were not applicable for service industries. However modern developments in manufacturing practices may increase the feasibility of this exchange. Lean manufacturing created a new model for manufacturing, which was also adopted by service industries. The adoption of lean has been beneficial for the service industry by: reducing non-value added activities, increasing product variety, and increasing focus on the customer. However, service industries may be misinterpreting what customers desire. This is creating a barrier to the applicability of manufacturing practices to service. Mass customization is the proposed model for both manufacturing and service. Mass customization is characterized by: flexibility and responsiveness, focus on individual customers, value chain integration and disaggregation, empowerment of employees and teams, KM, and networked organization. This model has been proposed as a common paradigm for manufacturing and service for improved performance.

Glover, Poopunsri, and Hurley (2014) identified that non-profit organizations need to improve effectiveness, productivity, and efficiency due to rising costs, less funding, and higher demand from clients. The authors analyzed how to effectively apply lean principles, or the Toyota Production System, to non-profit organizations. They observed that recent lean implementations have been misguided, applied for popularity or benefits seen elsewhere, or incomplete. They claimed that an understanding of the need must be the first step in lean implementation. The authors presented a case study demonstrating lean implementation at a food bank. In the case, the current state was defined, a vision of the future was established, key performance indicators (KPIs) were developed, and improvements were made in short intervals or on a continuous basis. The authors made several proposals for future research, including: how lean can be more transferable to non-profit organizations,
how to successfully practice lean in non-profit organizations, and the difficulty of applying various lean methods to non-profits.

Mirdad and Eseonu (2014) realized that there was a low percentage of successful lean implementation, possibly 10% or lower. The authors provided the following explanations for the failures: inappropriate strategies, incorrect tools, and poor selection of performance measures. The authors found that lean must be adopted completely and as more than a set of tools. Through the use of surveys, the authors found that confusion amongst lean adopters exists regarding its principles, practices, and performance measures.

1.3.1 Organizational Reliability/Redundancy. Martin Landau (1969) analyzed redundancy in organizations. He explained that the common view of redundancy is negative, implying waste. He acknowledged that many strive for zero redundancy as the ultimate achievement in economy and efficiency. However, he maintained that redundancy may be used to reduce errors and increase flexibility. Redundancy can be used to ensure that a system does not experience catastrophic failure when components of it fail.

1.3.2 Manufacturing Practices in Service Industry. Theodore Levitt (1972) claimed that inefficiencies and primitive methods in service industries are due to people's views of those systems. Levitt argued that there needed to be a shift in taxonomy of service industries to viewing these industries as closely related to manufacturing. The result would be a view of service industries that is in line with manufacturing practices. Levitt described manufacturing practices as including careful planning, control, automation, quality auditing, and reviews for performance improvement and customer feedback. He claimed that all industries are service industries; the only difference between them is the extent of the service operations. He warned that if a manufacturing view of service industries is not adopted, insufficient resources will be devoted to process improvement in these industries.

2.1 Systems Thinking and Knowledge Management
Ray Stata (1989) identified a decline in competitiveness of United States firms due to a lack of management innovation. To be innovative, management requires new technology, specifically knowledge, tools, and methods. Stata asserted that, in the future, organizational learning may be the only sustainable competitive advantage. Learning is based on knowledge and insights, and influences behaviors and actions. Organizational memory is the basis of learning, and it depends on the retention of knowledge. KM is necessary to ensure that knowledge is not lost when employees depart from an organization. Stata sought to develop techniques to increase the rate of organizational learning. Stata identified the need for ST when enacting organizational change. If decisions do not consider the organizational system holistically, unanticipated and negative consequences may result. Stata emphasized the need for future leaders to master organizational design to align operations with their organization’s mission. Stata explained that an important characteristic of organizations is elimination of delays in responses to the external environment. Not only do these responses need to be rapid, but also accurate. Learning can be modelled by learning curves, where time is the independent variable and some metric for the outcome of learning is the dependent variable. The slope of the learning curve is based on problem solving abilities, which depends on organizational learning. Poor communication is commonly the root cause of problems. Organizational boundaries create barriers for communication. Quality improvement can be a tool to break down these boundaries, at least temporarily, and thus facilitate more rapid organizational learning. The learning process is dependent on organizational values and culture.

Peter M. Senge (1990) demonstrated the need for learning organizations and provides resources for building learning organizations. He explained that organizations need to go beyond adaptive learning and develop generative learning. This switch represents a shift from primarily reactive learning to both reactive and proactive learning. In order to adopt generative learning, holistic views of systems are necessary (i.e., ST). In learning organizations, leaders drive learning. This involves creating a shared
vision, creating and developing mental models, and facilitating ST. The successful creation of a learning organization is based on developing organizational culture. Senge called for a new approach to organizational management where culture is formed based on the learning organization model.

Gao, Li, and Nakamori (2003) proposed using critical systems thinking and total systems intervention (TSI) to creatively manage human knowledge. Critical systems thinking is a systemic analysis tool and TSI is holistic implementation methodology. In a past study the authors concluded that critical systems thinking is an appropriate tool for application to human knowledge and KM processes. The authors defined two categories of organizational knowledge: static substance and dynamic process knowledge. Static substance knowledge is that which is accumulated and exists over time, and can be learned and shared. Static substance knowledge is broken down into three categories: visionary knowledge, objective and subjective knowledge, and generic knowledge. Dynamic process knowledge is equated to human activity for the organization. For managers, the proposed methodology will facilitate organizational unity and collaboration. For workers, it can create a systemic approach to communication and activities.

2.2 Systems Thinking and Lean Thinking

Molleman and Niepce (1998) compared and contrasted lean production (LP) and sociotechnical systems (STS) thinking with regards to work design, and examine the feasibility of combining the two in practice. Both LP and STS thinking place high value on workers as capable resources, but they differ in how they view the human in the system. LP primarily considers systems that do not display human characteristics, while STS thinking views a system revolving around humans. From the LP perspective, power and control do not come from the workers, but from the system surrounding them and subject matter experts. STS thinking is based on the power of the workers. The authors identified that the primary differences between the two are system boundary definitions, assumptions about workers, and control mechanisms used. The authors determined that these two perspectives cannot be combined piece by piece, but rather must be incorporated using a common paradigm based on the fundamental theories about people. They concluded that attempting to implement fundamental principles of LP and STS thinking simultaneously will likely lead to conflicts.

Oppenheim, Murman, and Secor (2011) created a list of 194 "do"s and "don't"s, referred to as Lean Enablers for Systems Engineering (LEfSE), as a tool for lean systems engineering (LSE). LSE is a combination of LT, systems engineering, and enterprise management. The LEfSE list is intended to be an enhancement of systems engineering to incorporate LT. The authors found, based on a survey, that the LEfSE guidelines are not widely used currently, but are needed.

Saurin, Rooke, and Koskela (2013) examined the applicability of LP to complex systems, such as service industries. The authors were particularly interested in the compatibility of LP to complex systems thinking, specifically for sociotechnical (soft) systems. They concluded that LP is applicable to complex systems. LP has the potential to eliminate unnecessary complexity. Complex systems thinking can enhance LP by: drawing attention to subtle inefficiencies, increasing resilience of the workforce, encouraging the use of slack, anticipating the side effects of slack, encouraging innovative control methods.

Wooward-Hagg et al. (2014) examined the implementation of LT in United States healthcare organizations. They found that there exist many cases where LT was only implemented on a small scale, or the implementation failed. The authors concluded that the latter may be due to implementation of lean tools only, neglecting systemic implementation, or the failure to sustain lean practices by enacting cultural changes. The authors recognized that differences between manufacturing and healthcare industries may hinder effective implementation and sustenance of lean practices in healthcare organizations. They realized that systems approaches may assist lean implementation into the management of healthcare organizations. The authors created a framework based on evidence based management for implementing evidence into practice. This framework consists of the following
steps: 1) Extraction of Operational Evidence, 2) Synthesis into High-level Theoretical Construct, 3) Development of Mid-level Theoretical Construct, and 4) Translation into Operational Models.

### 2.3 Knowledge Management and Lean Thinking

B.J. Hicks (2007) identified that some information management systems are not well aligned with the organizations that employ them or with other information systems in place. The practice of information management involves organization, visualization, and representation of information, and its flow to the end user. He proposed using LT to improve application and performance of information management systems. The principles of lean to be applied to information management are value, value streams, flow, pull, and continuous improvement. Hicks identified four types of waste in information management systems: failure demand, flow demand, flow excess, and flawed flow.

#### Theoretical Framework/Proposed Methodology

Beer emphasized the need for knowledge sharing amongst the management systems (subsystems Three, Four, and Five) of the VSM (Beer, 1984). KM will facilitate knowledge sharing and retention of not only the management team, but all employees. This will assist subsystem Five, the policy generator, in its task of monitoring subsystems Three and Four. The sharing of information between subsystems Three, Four, and Five will be spread to subsystem One, operations, via subsystem Two, which serves regulatory purposes. Conversely, knowledge gained by operations (subsystem One) will be transmitted to management by subsystem Three. Subsystem Three is a component of the management structure which audits operations. Thus, subsystem Three fills a critical role of collecting information from operations and communicating it management. Organization-wide knowledge sharing is feasible, allowing the flow of knowledge between operations and management via subsystems Two and Three.

KM can be used in conjunction with the Lean Enablers for Systems Engineering (LEfSE) presented by Oppenheim, Murman, and Secor (2011). KM may be used to accomplish some of the LEfSE, such as the following. Only first tier LEfSE are provided (i.e., number 3.5), not second tier LEfSE (i.e., number 3.5.1).

- “3.5 Use Efficient and Effective Communication and Coordination” (Oppenheim, Murman, and Secor, 2011, p. 45)
- “3.7 Make Program Progress Visible to All” (Oppenheim, Murman, and Secor, 2011, p. 46)
- “5.3 Use Lessons Learned from Past Programs for Future Programs” (Oppenheim, Murman, and Secor, 2011, p. 48)
- “5.4 Develop Perfect Communication, Coordination and Collaboration Policy across People and Processes” (Oppenheim, Murman, and Secor, 2011, p. 48)
- “6.4 Nurture a Learning Environment” (Oppenheim, Murman, and Secor, 2011, p. 49)

Levitt (1972) demonstrated the need to apply manufacturing processes to service industries to increase efficiency. This shows that manufacturing techniques such as lean principles can be applied to service organizations such as the OSU EEC. Application of lean philosophies to the OSU EEC will place emphasis on delivering values to stakeholders. The primary stakeholders are clients and OSU EEC employees. Lean will enhance delivery of work products to clients by process improvement; it will also ensure delivery of value to employees through collaboration with KM.

As proposed by Hicks (2007), LT can be applied to KM. Without a self-checking mechanism, such as LT, KM systems can become wasteful and fail to deliver value to users (Hicks, 2007). To apply LT to KM, the OSU EEC must first define what value is to be obtained from shared information.

Several researchers (Womack & Jones, 1996; Glover, Poopunsri, & Hurley, 2014; Mirdad & Eseonu, 2014) have discovered that lean implementations are frequently inappropriate or incomplete. At its roots, lean production was systemic by seeking improvements throughout the value chain. The similarities between ST and LT are apparent when considering their goals of analysis. As previously discussed, ST aims to understand the structure of systems, getting deeper than the tip of the iceberg.
(Anderson & Johnson, 1997). Lean uses tools such as Ishikawa Diagrams for root cause analysis.
Thus, the desire to seek the root cause of events observed is shared between ST and LT. Recent
applications of lean practices fail to adopt the complete philosophy, but rather focus on discrete
components of it (Womack & Jones, 1996). Such superficial applications of LT may fail for one of two
reasons: either the root cause of the problem is not addressed, or unanticipated side effects will result.
At this point it is necessary to make the explicit connection between ST and LT. This can be achieved
by enhancing the implementation of lean theory using ST. Mollemand and Niepce (1998) took a step
in this direction by determining that lean production and sociotechnical (soft) systems thinking are
compatible for application. Additionally, Saurin, Rooke, and Koskela (2013) determined that lean
practices are applicable to complex systems, such as those in service industries, which the OSU EEC
is. Furthermore, these authors suggested that future works should work to combine lean theory with
other disciplines and systemic theories (Saurin, Rooke, & Koskela, 2013). Woodward-Hagg et al.
(2014) also determined that ST provides feasible approaches for organizational lean adoption.
Application of LT using ST will ensure systemic implementation of lean practices and that the
appropriate tools are adopted.

The application of the VSM incorporating LT with KM support will be most effectively accomplished
using an established methodology. Checkland’s SSM is well suited for the task. SSM is concerned
with aligning theoretical frameworks and models with real world scenarios. This can be used to apply a
single model to a real world scenarios, or, as proposed here, synthesizing several theories for
application to an actual organization. SSM intends to allow iterative implementation, facilitating a
learning process. This will ensure that eventually an appropriate solution is arrived at. Being a
technique of SST, there is no end goal or objective. Rather, SSM allows iterations as learning takes
place (Checkland, 2000).

Both encompassed in the field of ST, SSM and VSM provide similar organizational configurations.
Checkland’s SSM, presented in Checklad (1985a), provided the EROS (Environment, Relation,
Operations, Support) model for business operations. This model consists of wealth-generating
operations (O) operating in an environment (E) with an enabling support system (S) through a relation
(R) between O and S. Beer’s VSM, presented in Beer (1984), can be viewed as a more complex
version of the fundamental EROS model. The VSM is provided in Exhibit A2 in Appendix A. It
contains operations, which interact with an external environment with the support of regulatory and
management systems. This provides evidence that the two are compatible. However, the VSM is a
structure to be applied to an organization; SSM, on the other hand, does not have such an ending
objective as it is a methodology for implementation.

The synthesis of Beer’s VSM, KM, and lean principles integrated into the OSU EEC using SSM will
provide a sustainable management framework for this organization. A diagram of this methodology is
provided in Exhibit 4. The end result will be organizational restructuring around the VSM, with KM
systems for knowledge retention and sharing, and processes that focus only on value-adding activities.
This management structure will prove useful beyond the context of the OSU EEC. Other dynamic non-
profit organizations may benefit from adoption of the proposed management structure. Eventually the
proposed concepts may be applied beyond the context of dynamic non-profits to other organizations.
Conclusions and Future Work

Lean thinking was developed in the manufacturing sector. Levitt (1972) claimed that the service sector must adopt manufacturing techniques. Multiple authors (Bowen and Youngdahl, 1998; Glover, Poopunsri, and Hurley, 2014) have found that LT is applicable to service industries. LT tools, such as value stream mapping, root-cause analysis, and 5S, can serve as starting points for implementation of LT at the OSU EEC. These tools will help by identifying waste and shortcoming in delivering value to stakeholders. Value stream mapping can help to identify bottlenecks in the process of generating reports for clients. Root-cause analysis can be used to assess particular problems observed during report generation. 5S may be used to facilitate equipment management or to cleanup electronic file directories. The use of LT tools is a fine method for beginning lean implementation, but a deeper level of adoption is necessary to reap the full benefits.

Mirdad and Eseonu (2014) found that implementation of LT often fails. The reasons for failure provided by the authors indicate inadequate planning or poor decision making (Mirdad and Eseonu, 2014). ST helps managers gain a holistic perspective of operations. This can greatly enhance planning and decision making because interactions between system elements are understood. Thus, ST can help to anticipate consequences of modifications to elements of a system. The OSU EEC frequently enacts changes to its operations. Such changes may include modifications to report structure, employee expectations, or organization-wide projects. Applying ST will allow managers to analyze how decisions impact several aspects of the organization.

Future works tangential to this project may develop similar structures for organizations besides dynamic non-profits. Implementation in a different setting may have a different flavor than that experienced here. For example, applying these theories at a manufacturing firm will have to consider intense competition. Applying LT to manufacturing may present less challenges than its application at a service industry such as the OSU EEC as lean was originally developed in a manufacturing setting (Bowen and Youngdahl, 1998).

Future work will develop the proposed theoretical framework into a feasible management structure. The developed structure will be implemented at the OSU EEC using SSM. Performance measures will be developed, with an established baseline, to ensure that the end result yields operational improvements.
References


**Acknowledgements**

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Appendices

Appendix A. Supporting Exhibits

Exhibit A1. OSU EEC Staff Structure.
Exhibit A2. The VSM (Beer, 1984).
About the Authors

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Joseph F. Junker, P.E. is Director of the Energy Efficiency Center (EEC) and Industrial Assessment Center (IAC) in the School of Mechanical, Industrial and Manufacturing Engineering (MIME) at Oregon State University (OSU). Under his direction and mentorship, the OSU EEC/IAC has performed over 200 energy efficiency assessments of small to medium sized industrial facilities in a wide range of sectors including glass and metals, forest products and secondary wood products, food processing, plastics and composites, materials production, high tech and general manufacturing. Other industrially related projects at OSU have included organizing twelve semiannual NW Industrial Efficiency Forums, offering multiple trainings and workshops on industrial technology efficiency improvements, coordination of ITAP, a Northwest Industrial Technical Assistance Provider group, and collaboration with the Oregon Manufacturing Extension Partnership to provide direct assistance to Oregon Manufacturers. Junker is also principal of Joseph F. Junker Consulting and in that role has performed 18 U.S.DOE funded "training" Energy Savings Assessments (3-4 day engagements) throughout the United States to assist very high energy use facilities in improving their system efficiencies.
CHAPTER 4

4   Refereed Conference Paper 2

The following chapter has been published in the proceedings of the International Society for the Systems Sciences (ISSS) 2015 Annual Conference under the title “Synthesizing Systemic Intervention Approaches: Combining Viable System Model, Knowledge Management, and Toyota Production System for a Sustainable Holistic Management Model.”

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Synthesizing Systemic Intervention Approaches: Combining Viable System Model, Knowledge Management, and Toyota Production System for a Sustainable Holistic Management Model

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ABSTRACT

Non-profit service organizations existing in dynamic environments are often presented with management challenges, such as necessity for non-centralized management structures, knowledge retention, and meeting diverse stakeholder demands. Many intervention approaches exist to address these challenges, such as the viable system model (VSM), knowledge management (KM), and the Toyota production system (TPS). These approaches each stem from specific weltanschauungen (world views), capable of leading interventions in particular problem contexts. Previous work such as total systems intervention, creative design of methods, and boundary critique provide roadmaps on how to combine different approaches to act in complex problem contexts. However, they require the analyst to possess significant systems thinking knowledge. This research explores a complementarist framework to assist those that are not educated in systems thinking in intervening in complex problem contexts. The proposed framework is presented through a case study based on a non-profit service organization that performs knowledge-based project work in a dynamic environment. The development of the proposed complementarist approach is presented through 1) the problem context definition, 2) selection of applicable intervention approaches, 3) the analysis and matching of relevant literature to the problem context, and 4) illustration of the resulting framework for the case study organization. Discussion on potential future applications and development of the proposed framework are also presented.

Keywords: Engineering management, systems thinking, viable system model, knowledge management, Toyota production system, organization, non-profit, service, dynamic

Introduction

Some organizational management challenges are internally-driven, such as adhering to non-profit budgets, applying knowledge to complete work tasks, and creating management structures to sustain viable operations. Conversely, some challenges are environmentally-driven, such as maintaining knowledge despite rapid turnover of the workforce and meeting diverse stakeholder demands. If organizational performance is to be improved, internal and external challenges must be addressed. Without guided intervention approaches, ad hoc management initiatives can have detrimental effects (Jackson, 2003). Ad hoc structures prohibit organizations from reaching their full potential by not fully utilizing collaborative potential (Bryan, Matson, & Weiss, 2007). When collaboration is poor, organizational performance suffers due to poor utilization of knowledge (Mohamed, Stankosky, & Murray, 2004). Sy and
D’Annunzio (2005) found that matrix organizations often suffer from misaligned goals, unclear roles and responsibilities, ambiguous authority, lack of matrix guardian, and silo-focused employees. A holistic framework for management intervention would help inform managers of more effective practices to improve performance through (Jackson, 2003).

As a starting point, let us consider a non-profit service organization that performs knowledge-based project work in a dynamic environment. In this case, a matrix organizational structure is likely to be used as it combines the benefits of functional and project structures (Sy & D’Annunzio, 2005). Such an organization faces several management challenges such as the necessity for a non-centralized management structure, knowledge retention, and meeting diverse stakeholder demands. Three intervention approaches that are designed for such problem contexts are viable system model (VSM), knowledge management (KM), and Toyota production system (TPS; also known as lean manufacturing).

There are several intervention approaches to address management challenges, such as VSM, KM, TPS, soft systems methodology (SSM), operations research, and organizational behaviour. These were developed in different problem contexts, with different weltanschauungen (world views), to achieve various outcomes. The weltanschauung of an intervention approach drives its methods and outcomes (Jackson, 2003). Managers who wish to act on experienced management challenges should consider their own problem context and desired weltanschauung to design an applicable intervention.

One intervention approach may not be sufficient to address a vast set of management challenges (Jackson, 2001). Methodologies exist to synthesize approaches, such as SSM, total systems intervention (TSI), boundary critique, and creative design of methods. These methodologies require working knowledge in the field of systems thinking. To those not educated in systems thinking, these methodologies would likely appear to be prohibitively rigorous (Jackson, 2003).

There is a need for a model to guide managers to appropriate intervention approaches without necessarily requiring systems thinking knowledge. With such a model, managers would consider how their problem context and weltanschauung match those of existing intervention approaches. From this model, an intervention approach, or combination of approaches, will be prescribed to suit the manager.

VSM, KM, and TPS have been selected as promising intervention approaches for a non-profit service organization that performs knowledge-based project work in a dynamic environment, which presents a diverse set of management challenges. These three intervention approaches each address a partial set of the mentioned challenges, but a single intervention approach does not exist to address all of the challenges. Combining the three provides enough diversity to address the three primary management challenges in the case considered: the necessity for a non-centralized management structure, knowledge retention, and meeting diverse stakeholder demands. An ideal intervention would synthesize these to extract beneficial elements.
from each. This is referred to as a complementarist approach (Jackson, 2003). The three approaches have differing weltanschauungen and were developed to act in differing problem contexts. A manager acting at an organization such as the one considered here would benefit from a model to define several problem contexts and the approach to apply in each. Such a model could also advise, in a complementarist approach, how to prioritize the simultaneous application of multiple intervention approaches, thus guiding a holistic management intervention.

**Viable System Model**

Efforts must be made to ensure cohesion of managers and workforce. If such considerations are not made, the “silo effect” may occur, where components of the organization are not effectively collaborating. This can have detrimental effects in organizations such as competing or conflicting objectives, organizational policy or structural breakdown, slow decision making, poor coordination in completing products, employee confusion, poor communication, poor sharing of resources, and poor training (Sy & D’Annunzio, 2005). The viable system model (VSM) frames organizations in terms of roles and interactions, opposing the blame-based culture that may result from hierarchical organizational structures (Beer, 1984).

According to Stafford Beer, creator of VSM, organizations must consist of particular roles and interactions to ensure viability. A viable organization is one that is capable of existence independently of other entities in its environment. Organizations can exist in non-viable states, but they are at risk of failure, or at least not meeting their potential (Beer, 1984). Thus, organizations are benefitted by striving for viability.

Viability is achieved by components of an organization filling roles defined by VSM. There are five necessary components, referred to as subsystems, within VSM. Subsystem 1 consists of operational elements in an organization. This subsystem consists of the workers generating products or services for the environment. It is broken into components based on their contribution to the environment. Each subsystem 1 component has its own management unit. Subsystem 2 coordinates the operations of subsystem 1. It maintains stability and smooth operations. Subsystem 3 provides resources to subsystem 1, intervening with management of subsystem 1 components when necessary. Subsystem 3* sporadically audits the outputs of subsystem 1 to inform subsystem 3. Subsystem 4 observes the environment to help the organization react and plan for the future. Subsystem 5 is in charge of organizational policy. It represents the organization in the outside world. It also supports subsystems 3 and 4 (Beer, 1984; Vidgen, 1998). Each subsystem has a limited role to play in an organization. A breakdown in any of the subsystems will lead to non-viability of the organization. VSM is focused on control to facilitate effective collaboration, which depends heavily on communication throughout the organization (Beer, 1984).

VSM uses the law of requisite variety to guide an organization’s interaction with its environment. This law states that variety in the environment should be addressed with variety in the organization. The goal is for an organization to possess enough variety
to match the variety of its environment, meaning that it has the tools to address any threat the environment poses (Beer, 1981; Beer, 1984). This can be seen as having a plan for any scenario the environment presents. One method to boost variety within the organization is by using conferences to encourage participation (Beer, 1981). Thus, organizations benefit from using groups rather than individuals to complete tasks and fill roles, encouraging a collaborative workforce.

Creating a non-centralized management structure (management delegation) is one technique to reduce the variety in an organization’s environment (Beer, 1981). This reduces the burden of an organization boosting its own variety to match that of its environment. For example, subsystem 5 should focus its efforts on policies of the organization, allowing others fill complementary organizational roles. It should not act on the roles of any other subsystem unless a subsystem lacks sufficient variety to address a threat to the organization (Beer, 1981). A top-heavy organizational structure can threaten its own viability (Jackson, 2003).

VSM supports viability of an organization as a whole, but advises against subsystems seeking viability in their own right (Vidgen, 1998). However, VSM exhibits recursion, meaning full versions of the VSM structure are contained within every VSM structure, creating infinite levels of recursion. According to the recursive nature of the VSM, operational elements within subsystem 1 must be full viable systems within themselves. This means that each level of recursion contains a complete VSM structure within each of its subsystem 1 components, and its whole structure is within a subsystem 1 component of another VSM structure (Beer, 1984). This does not mean that subsystem 1, or any other subsystem in VSM, should attempt to be viable (Vidgen, 1998). Non-centralized management structures prevent the concentration of too many roles on too few employees in the organization, thus simultaneously boosting variety and discouraging attempts at viability over performing dedicated roles.

**Knowledge Management**

Drucker defines a knowledge worker as “a knowledge executive who knows how to allocate knowledge to productive use” (as cited in Nonaka and Takeuchi, 1995, p. 7). In this research, knowledge-based work is defined by work tasks completed by knowledge workers.

Direct experience is the most valuable method of learning (Nonaka & Takeuchi, 1995). Because of this, experienced workers have knowledge that is not expected of new workers (Levy, 1965). This creates a management challenge because distribution of knowledge must take place to ensure that workers can complete their tasks. Employees that can independently complete their tasks are valuable to an organization. But knowledge, and thus value to the organization, is developed over time (Davenport & Prusak, 1998; Levy, 1965). Time can be saved if knowledge is transferred, rather than having to be regenerated for each worker that requires it (Fong & Kwok, 2009). Not only must knowledge be shared amongst the workforce, but it
also must be retained to be applied beyond the tenure of any member of an organization.

In this research, rapid turnover of workforce refers to when employee tenures at an organization are short. This presents challenges in sustaining a sizable workforce and utilizing the knowledge gained by employees. When a worker possesses valuable knowledge, if action is not taken to retain it, the knowledge will be lost when this person leaves the organization (Fong & Kwok, 2009). Knowledge loss has detrimental effects on the organization. One potential effect is the loss of output quality when knowledge is no longer present in an organization. Another effect is an increased burden of management to train a replacement worker, which occurs more frequently in rapid turnover environments due to a higher frequency of employee departures. Allowing new employees access to an organization’s knowledge base can aid training efforts (Nonaka & Toyama, 2003).

Knowledge management (KM) strives to make the best use of knowledge within and created by an organization to improve operations (Davenport & Prusak, 1998). It fundamentally defines knowledge in two ways: tacit and explicit. Tacit knowledge is contained within an individual and difficult for others to access. Explicit knowledge is documented and available for others to access. A primary goal of KM is to make the conversion from tacit to explicit knowledge so that it may be shared and applied. The four steps of KM can be described as 1) collection (individual tacit to group tacit), 2) retention (tacit to explicit), 3) distribution (separate explicit to systemic explicit), and 4) application (explicit to tacit) (Nonaka, 1991; Nonaka, Umemoto, & Senoo, 1996). Organizations experiencing rapid turnover of the workforce benefit from retaining and sharing knowledge by converting it from tacit to explicit knowledge before workers leave the organization.

**Toyota Production System**

Complexity is defined by emerging characteristics due to the structure of a system. Emergence in complex production systems can present higher risk of production problems compared to simpler systems, thus creating management challenges (Calvo & Flumerfelt, 2015; Senge, 1990). Two characteristics of operations that increase complexity are many steps in production and dependent events. Having many steps in a process is an example of detail complexity (Senge, 1990). Having more steps in a production process means there are more potential sources of error or defects. It may also mean that there are many different tasks involved in production. According to the law of requisite variety, an organization with a large variety of tasks demands a large variety of resources (Beer, 1984).

Another feature that increases complexity in operations is dependent events. When sequential tasks must be performed in series, rather than in parallel, they are dependent on each other. Dependent events represent dynamic complexity because the consequences may become apparent as time passes (Senge, 1990). A given task cannot begin until the preceding task is complete. In this case, variability in task completion time can be detrimental (Hopp & Spearman, 2001).
Constraints are limits placed on operations. Project work often has constraints placed on it. Commonly, project constraints exist to meet quality expectations, limit costs, and limit duration to completion (Larson & Gray, 2011). These requirements are generally set by the owner of the project. The owner is in control of the project and can terminate it at any time (Checkland, 2000). The owner is often the individual or agency funding the project.

Toyota production system (TPS), later known as lean manufacturing, was developed in the manufacturing sector and has been adapted for service organizations (Lander & Liker, 2007). The primary goal of TPS is cost reduction. There are three sub-goals necessary to achieve the primary goal; including quantity control, quality assurance, and respect for humanity. Its method to achieve these goals is eliminating waste in operations, which leads to better quality and less costly production (Monden, 1983). TPS uses several tools to identify waste and seek opportunities for improvement; however it should be viewed as a systemic approach, not simply a set of tools (Lander & Liker, 2007). It identifies four concepts for process improvement; including just-in-time production, automation, flexible workforce, and creative thinking or innovative ideas. These concepts are addressed by eight systems and methods (Monden, 1983). Some of these are more difficult to connect to low volume, high variety environments, such as service organizations, because of the roots of TPS being in high volume automobile manufacturing (Lander & Liker, 2007). The TPS methods that will be most applicable in the case considered here are reduced setup time, employee involvement and empowerment, quality at the source, equipment maintenance (not literally equipment in this case), and standard operations. These principles can help service organizations in meeting diverse stakeholder demands.

Framework Development

Intervention Application Literature

Selected literature articles, containing real world applications of VSM, KM, and TPS in environments similar to the example case presented here, were gathered. Ten articles with appropriate applications were gathered for each of the three intervention approaches, for a total of 30 articles. The six elements of the CATWOE methodology were recorded. CATWOE is a mnemonic for customer (C), actor (A), transformation (T), weltanschauung (W), owner (O), and environment (E). It is a tool of SSM to define systems of purposeful activity (Checkland, 2000). It was used here to describe applications of the three intervention approaches to real world cases. The goal was to identify similarities and differences in the approaches and their applications.

Once CATWOE elements for all articles were noted, generalizations were made about each of the three intervention approaches. A key component of this was categorizing the stakeholder elements: customer (C), actor (A), and owner (O). Categories of stakeholders included company, consultant, government agency, citizens, academic institution, and researcher. Figure 1 gives a basic summary of the categorization of C, A, and O. Number of Customers, Actors, and Owners is the number of these stakeholders identified in the application articles. “Most Common” is which stakeholder appeared the most in the articles considered. “Frequency of Most
“Common” is how many times (out of the ten total articles for each approach) the most common stakeholder appeared.

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Figure 1. Application Literature Summary for C, A, and O

After analysing stakeholders, focus was shifted to the transformation (T), weltanschauung (W), and environment (E) for each intervention approach. It was determined that Venn diagrams were the most effective way to organize and display the findings for these CATWOE elements. Figure 2 shows a Venn diagram for T. In practice, VSM, KM, and TPS are all used to diagnose problems or for auditing functions.

![Transformation Venn Diagram](image)

Figure 2. Application Literature Transformation Venn Diagram

Figure 3 shows a Venn diagram for W. The only weltanschauung shared by VSM, KM, and TPS is responding accurately and rapidly to the environment. Three have differing methods of responding to the environment, but all value interactions with
the environment. Many other weltanschauungen are shared between pairs of two of the three intervention approaches.

**Figure 3. Application Literature Weltanschauung Venn Diagram**

Figure 4 shows a Venn diagram for E. Unlike for T and W, the three intervention approaches share many environmental factors, implying that they are applied in similar cases.
Based on observations regarding stakeholders (C, A, and O), and the other CATWOE elements, four categories of intervention approach definition were created.

**Developing the Framework**

*Four Definition Categories*

Four categories were developed to define intervention approaches. The categories are scope, inspiration, solution, and ideal. These categories each range between two extremes. Scope describes on what level of an organization intervention occurs, ranging from organizational operations to organizational design. Inspiration considers what gives meaning to the intervention, ranging from resource (internally) driven to context (environmentally) driven. Solution describes what the goal of intervention is, ranging from optimal amount of resources to right, or adequate, amount of resources. Ideal implies what the intervention approach values, ranging from organizational culture to organizational control. Intervention approaches may not be defined by either extreme. In this case, it assumed that they have either dual consideration for the extremes or indifference between the extremes.

*Defining Intervention Approaches*

VSM, KM, and TPS were each defined using the four categories of definition.

VSM functions using the law of requisite variety, which states that an organization should contain enough variety to address the variety of its environment (Beer, 1981; Beer, 1984). It does not state that an organization should be prepared to address every possible scenario in all existing environments. It teaches that an organization should prepare itself for the threats of the environment, and when an unanticipated threat
arises, the organization should adapt using the autonomy granted throughout (Jackson, 2003). Therefore, it aims for the proper amount of resources to act in its environment, not necessarily the optimal amount of resources. VSM is primarily concerned with viability of an organization, not the specific stock of resources to achieve this. The method of achieving viability is based in the theory of organizational cybernetics, the science of effective organizations. This theory depends on organizational control (Beer, 1981). VSM proposes specific roles and interactions within an organization, and interactions between the organization and its environment, making it context driven (Beer, 1984). Thus the scope of VSM’s intervention is organizational design.

According to Monden (1983), TPS is based on reducing waste in operations. It does not heavily consider organizational design, thus its scope is generally limited to organizational operations. It is internally driven, seeking optimality in utilization of resources, with a goal of eliminating waste. TPS strives for waste elimination with the understanding that this is an unreachable goal. In this way, TPS emphasizes continuous improvement, which requires an organizational cultural shift.

KM falls close to the centre of the spectrums of all four categories. KM is motivated by both internal operations and the environment, seeking to exploit knowledge from both (Grant, 1996). It is ultimately driven to improve organizational operations, but encourages modifying organizational design to support this if necessary (Grant, 1996; Nonaka & Takeuchi, 1995). KM shares the concept of continuous improvement with TPS (Hicks, 2007; Nonaka, 1991). This implies a tendency for KM to strive for optimality in operations, rather than settling for adequate use of resources. KM depends on cultural shifts to make the most effective use of knowledge and to seek continuous improvement, including continuous innovation (Davenport & Prusak, 1998; Nonaka & Takeuchi, 1995). As a result, it is expected that the effective utilization of knowledge will spread throughout the organization. This implies an interest in organizational control in addition to organizational culture.

**Beneficiary Identification**

Upon definition of VSM, KM, and TPS in terms of the four categories developed, it was noted that, when applied in organizations, these benefit different stakeholders. The two categories of beneficiaries are workers and management. TPS primarily benefits workers by empowering them and providing support in operational settings (Monden, 1983). VSM primarily benefits management as it considers the functioning of the organization as a whole, not considered with how subsystem 1 workers do their work (Jackson, 2003). Primarily worker benefiting interventions focus on supporting workers and improving the work they do. Primarily management benefiting interventions act in the organization on a larger scale, which does not consider the workers directly, but control over the work they do.

**The Proposed Framework**

A framework for intervention definition and application has been created. This framework is provided in Figure 5. The four axes explain the emphasis of the intervention approaches within the graph, using the four definition categories
developed. The beneficiary line appears diagonally across the graph, from the corner where the Scope and Inspiration axes meet to the corner where the Ideal and Solution axes meet. This line is not intended to be definitive divide, but a progressive trend, where the distinctions are stronger in the far corners than through the diagonal where the line is drawn.

Using the Proposed Framework
The proposed framework’s most useful feature is likely the ability to prescribe intervention approaches based on a given problem context. An organization can evaluate the circumstances of a particular problem context, based on a situation or desired state, based on the four axes and primary beneficiary. By selecting values for at least two of the axes, a point on the graph can be identified. Existing intervention approaches will be placed appropriately on the graph. Whichever intervention approach is closest to the given point will be assumed to be the best for the given problem context.

If a complementarist approach is desired, and multiple intervention approaches have been deemed applicable, the proposed framework will suggest precedence for the selected approaches. The selected approaches should first be placed on the graph. When a problem context arises, a manager can find the corresponding point on the graph using at least two axes. The intervention approach on the graph closest to the desired point should be primary; the next closest should be secondary, and so on. The ranking of intervention approaches will guide the manager to how much emphasis to place on each of the intervention approaches.
Case Study

Background

The Oregon State University (OSU) Energy Efficiency Center (EEC) is a student-operated organization with faculty oversight that engages in outreach to promote energy and resource efficiency. The primary project of the EEC is the Industrial Assessment Center (IAC), which exists primarily to perform industrial energy efficiency assessments. Other grants have been earned by the EEC to pursue other projects, including assessments of facilities in other sectors. Additionally, the EEC works to increase awareness of energy efficiency and provide resources for the public to self-assess energy efficiency measures (OSU Energy Efficiency Center, n.d.).

The EEC has a multi-faceted mission, which includes performing facility assessments, providing energy efficiency resources for the public, developing skills of university students, facilitating a connection between academia and industry, providing research opportunities, and generating funding flow through the university (OSU Energy Efficiency Center, n.d.). As a result, the EEC has many stakeholders, including the EEC director, faculty, and employees; assessment clients; OSU administration and some faculty; and the general public.
As a non-profit service organization that performs knowledge-based project work in a dynamic environment, the EEC presents several management challenges. These challenges include developing a non-central management structure, retaining knowledge in a rapid turnover environment, and meeting diverse stakeholder demands. This case matches the one discussed earlier, where VSM, KM, and TPS were selected to guide intervention.

Management Structure
One recent EEC management modification has proven to be beneficial, but would likely benefit from additional guidance. The director established a management structure based on management segments of focus (SOFs). The goal was to distribute management tasks amongst many analysts, rather than all being handled by the director and graduate student operations managers as in the past. This intervention came at the time that the director began scaling back his involvement and desired to delegate tasks to others. The segment of focus (SOF) structure also provides opportunities for analysts to be more involved in EEC operations and gain management experience.

EEC management tasks were divided into several SOFs and assigned to various workers, based in existing experience, skill, or interest. Each SOF has a lead and an understudy, who supports the lead and is intended to become the next lead. Leads are not intended to do all the work associated with their SOF, but to manage the necessary tasks and ensure fulfillment of the role. This has led to management silos, where SOF leads are fixated on their role, but lack coordination with other management roles. Ambiguity in roles of authority has also occurred due to the large management variety. A persistent challenge has been designing an effective avenue for SOF leads to provide operations managers with status updates in their respective SOFs.

Knowledge Utilization
Ideally, knowledge would be accessible to employees at point of use. Many employees begin their work at the EEC with little-to-no experience in industrial energy efficiency. This creates dependence on experienced staff to train new employees on technical analyses in addition to operational policies and practices. Once employees possess the foundational knowledge and skills for energy efficiency analyses, learning is driven by experience (Levy, 1965). As analysts gain experience at the EEC, their general and specialized knowledge grows.

The work at the EEC is knowledge-based. It consists of performing technical analyses, for which skills are expected to be developed while working at the EEC. When employees depart from the organization, much knowledge may be lost with them. This knowledge was likely developed over time during their tenure as an employee (Fong & Kwok, 2009). Being a rapid turnover organization, with average employee tenure of approximately two years, the EEC would benefit from improved knowledge retention.
The EEC uses shared digital storage spaces to make electronic resources accessible to employees. There are several shared spaces, including a network drive, an online database, online applications, and websites. Looking for a particular piece of information can lead to a searching process across storage spaces. Better definition and organization of shared storage spaces would be beneficial, allowing access to appropriate resources more quickly.

**Complex Operations and Stakeholder Requirements**

The deliverables of facility assessments are reports prepared for client companies. A report contains information about the client company and recommendations for process improvements and cost savings, which can include reducing energy use, reducing waste, and increasing productivity. The report generation process contains many mutually dependent events, combining the efforts of several employees, whom are all college students, meaning they have limited time and attention for EEC tasks. Furthermore, employees often require assistance in completing tasks if they are not experienced. For these reasons, there is much potential for bottlenecks to occur in the report generation process. Thus operational efficiency increases are desired.

Operations at the EEC are driven by requirements of stakeholders. Funding agencies place constraints on the assessment process in terms of total number of employee hours used, time to complete reports, and quality of reports. Continuation of funding depends on delivering reports subject to the constraints of funding agencies. Additionally, clients have expectations for assessment reports; some have special requests or needs that require accommodation. Since the reputation of the EEC and OSU depend on positive interactions with clients, delivering reports of maximum usefulness to clients is desired.

**Intervention**

Because of the need for a non-centralized management structure, retention of knowledge in a rapid turnover environment, and adhering to diverse stakeholder demands, the EEC is in need of a management intervention. A holistic management model is sought by the EEC, especially as the faculty director delegates more responsibility onto student managers. VSM has been selected to provide an organizational structure with strong and effective collaboration within it. KM will facilitate improved utilization of employee knowledge, including improved organization and retention of knowledge. TPS techniques are will aid in ensuring maximum value is delivered to stakeholders with minimal waste. VSM, KM, and TPS have been placed on the proposed intervention definition framework discussed earlier. The framework diagram with these approaches placed on it is provided in Figure 6.

VSM, KM, and TPS all have contributions to improving management of the EEC, but none of them alone address the entire problem. Therefore, these intervention approaches must be synthesized, combining crucial elements of each, to create a holistic management model for the EEC and similar organizations. The questions that remain are the following.
- Are VSM, KM, and TPS compatible with each other?
- Are VSM, KM, and TPS suitable for the EEC?
- How shall VSM, KM, and TPS be applied to the EEC?

Figure 6. Intervention Definition and Application Framework with VSM, KM, and TPS

Compatibility of VSM, KM, and TPS
Characteristics of E (environment) were discovered to be similar across the three intervention approaches, meaning that these interventions are applied to similar organizations. This is demonstrated in Figure 4. It has been identified that they all serve to address some part of the set management challenges at an organization such as the EEC. Furthermore, as Figure 1 shows, these approaches tend to be applied to similar types of customers with similar types of owners.

VSM, KM, and TPS for the EEC
According to the CATWOE analysis, previous applications of VSM, KM, and TPS match the EEC well in C, A, O, and E. Furthermore, W and E in previous applications of VSM, KM, and TPS serve the management needs at the EEC. These phenomena demonstrate that the collection of the three intervention approaches fit the case of the EEC.
Synthesizing VSM, KM, and TPS

There are conceptual elements of the three approaches that are shared between two, yielding strong pairwise bonds, which, fuse all three when all are considered. VSM and TPS share a goal of guiding operations within an organization. VSM does not particularly define how operational elements should act, but defines the method of controlling their actions (Jackson, 2003). To compliment this, TPS focuses on constantly seeking methods to improve operational elements (i.e., subsystem 1 in VSM). This involves delivering high quality to the customer, doing so in a timely manner, and with the least amount of waste possible (Monden, 1983). TPS aims to improve the operational elements, while VSM describes the way those operational elements should interact with the rest of the organization.

KM and TPS have customer- and user-centric orientations. TPS strives to produce the right product at the right time in the right quantity for customers (Monden, 1983). Similarly, KM strives to make relevant information available for a user in need, at the time of need (Davenport & Prusak, 1998). KM can be used in two ways. First, it can be used to gather, store, distribute, and utilize information from the environment (e.g., customers and competitors) to the organization, specifically through subsystem 4 of the VSM, which observes and responds to the environment (Teece, 1998). KM can also be used to collect, retain, share, and apply knowledge within an organization (Nonaka, 1991; Nonaka, Umemoto, & Senoo, 1996). KM provides inspiration for internal organizational communication, which VSM values heavily. Furthermore, a principle that TPS holds paramount is employee empowerment (Monden, 1983). This demonstrates that TPS values employees, who can be empowered by the information provided to them via KM.

One of TPS’s main foci is to serve customers’ needs and desires (Spear & Bowen, 1999). In the case of non-profit organizations, where an agency is funding the organization to serve a purpose, the funding agency is a customer in addition to the end user of the organization’s outputs. The non-profit organization must satisfy the needs and desires of its funding agency customers, because doing so will secure funding, thus allowing it to remain viable. TPS enhances value delivered to customers by process improvement (Bowen & Youngdahl, 1998). Process improvement ensures that viability is maintained (Leonard, 2009).

Application of VSM, KM, and TPS to the EEC

VSM, KM, and TPS all have something to offer the EEC in its management challenges. VSM is a robust template to strive for organizational viability. KM and TPS can be used to support the functioning of the subsystems included in VSM. In this way, the three methodologies will be synthesized to one holistic management model for the EEC.

VSM will be used to structure and define the roles within the EEC. KM will be used in several communication channels in the model. It will assist in gathering, storing, distributing, and utilizing information from the environment to the organization through subsystem 4. It will also assist subsystems 2 and 3* in resource planning and auditing, respectively, of the operational elements (subsystem 1). Lastly, KM will be
used to share information and knowledge between operational elements (within subsystem 1).

TPS will provide support primarily for subsystems 1, 2, 3, and 3*. It will apply feedback from the environment to operational elements (subsystem 1). At the same time, it will assist subsystem 1 in providing high quality outputs to the environment while reducing waste. It will aid subsystem 2 in managing the resources of subsystem 1. It will also assist subsystem 3* in auditing subsystem 1. Furthermore, TPS can benefit other components of the organization. It provides tools for auditing and criticism, which VSM alone lacks (Vidgen, 1998). It also provides the concept of continuous improvement, which will encourage the organization to constantly adapt to the environment. Figure 7 graphically summarizes the synthesis of VSM, KM, and TPS as it may be applied to an organization such as the EEC.

Figure 7. VSM with KM and TPS Framework

Limitations of the Proposed Framework
It is possible that some intervention approaches cover not just a point, but a region in the proposed framework graph as some interventions may be more applicable to multiple problem contexts, cover a larger portion of the space. It may be more
appropriate to model the intervention approaches as regions rather than points. These regions would likely have differing sizes and shapes.

Conclusions and Future Work

The need has been identified for a model to guide management interventions. Support for managers is needed to select and apply appropriate intervention approaches for given problem contexts. A framework was proposed to define and select intervention approaches for application in different problem contexts. This framework can be used as a guide for practitioners to either select an approach for intervention, or to establish precedence of multiple approaches if a complementarist approach is desired.

To illustrate the need for such a model, the case of a non-profit service organization that performs knowledge-based project work in a dynamic environment is considered; specifically the EEC. Such an organization would benefit from interventions by VSM, KM, and TPS. Each of these approaches addresses a part of the EEC management challenge set, but none of them are sufficient alone. VSM, KM, and TPS have been defined within the proposed framework, with their positions validated.

VSM, KM, and TPS have differing weltanschauungen and methods of intervention, but they are applied in similar cases based on CATWOE of previous applications. This, combined with theoretical connections, demonstrates that the three are compatible with each other and may be combined for a holistic intervention. Future work will develop a methodology for applying a synthesized model that consists of VSM, KM, and TPS for problem contexts similar to those of the EEC. The proposed framework will be validated for use at the EEC and similar organizations. Then opportunities for application in other types of organizations will be explored.

In the future, more intervention approaches should be included in the proposed framework to provide managers with the most complete set of solutions possible. Methodologies such as TSI and SSM may be used to design implementation of complementarist approaches identified in the proposed framework. The framework presented here is an early version of what is hoped to become an applied systems thinking methodology for organizational management intervention. The goal is to provide resources in the field of engineering management that utilize systems thinking without the practitioner having to study systems thinking.

REFERENCES


Chapter 5

5 Refereed Journal Paper Draft

The following chapter is a draft paper to be submitted to *Systemic Practice and Action Research.*
Applying a Framework for Complementarist Intervention Approaches to Service Organizations to Achieve a Sustainable Holistic Management Model

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ABSTRACT
Organizational management often faces complex problem contexts, requiring intervention for improvement. Many intervention approaches exist to achieve a purpose in real world applications. Each intervention approach was developed with a specific world view (weltanschauung), dictating its methods and purpose. In a complex problem context, a single intervention approach is insufficient to address all challenges faced. Combining multiple intervention approaches, bringing differing perspectives, facilitates holistic action. Several methodologies have been developed to combine multiple perspectives, including soft systems methodology (SSM), total systems intervention (TSI), creative design of methods (CDM), and boundary critique. Each of these methods has strengths and weaknesses. A barrier to their use in organizations is the requirement for systems thinking education. This paper presents a framework for defining and selecting approaches for intervention in complex problem contexts. It also provides a method for utilizing this framework to design holistic and effective interventions. A case study is discussed, where the proposed framework and method are applied to a small non-profit service organization that performs knowledge-based work in a dynamic environment. The proposed framework and application method are presented through 1) description of the need, 2) review of contributing literature, 3) presentation of the framework, 4) description of the method, and 5) illustration in the case study organization. Limitations, future development, and scope of applications of the proposed framework and method are discussed.

Keywords: Engineering management, critical systems thinking, soft systems methodology, system of systems methodologies, total systems intervention, creative design of methods, boundary critique, complementarist approach

Introduction
Systems thinking has become a valuable driver of organizational management. It can be used to gain a holistic perspective of an organization and design appropriate and effective solutions to management challenges (Jackson, 2003). Some systems thinking methodologies are primarily theoretical and do not provide much guidance for practitioners. Additionally, those who are not well educated in the field of systems thinking may find its methodologies inaccessible (Jackson, 2003). Midgley (1998) discusses a case where systems language created a communication barrier between researchers and organizational management. This presented challenges in comprehension for management and risked creating the impression that researchers were not valuing the perspectives of managers. Systems thinking researchers can
benefit organizational managers by designing methods in which systemic practices and concepts are encapsulated. This will allow managers to use and benefit from systemic practices without having education in systems thinking.

Systemic methodologies such as soft systems methodology, total systems intervention, creative design of methods, and boundary critique are concerned with combining multiple world views (weltanschauungen). These methodologies can be applied to combine multiple intervention approaches [in this article “intervention approaches” and “methodologies” can be viewed as interchangeable]. Methodologies are initially developed in given problem contexts, with particular weltanschauungen, for certain purposes. Methods and outcomes of an intervention approach are inspired by its world view (weltanschauung).

A single intervention approach may be insufficient in a complex problem context (Jackson, 2001). Organizations often face several management challenges. Individual intervention approaches may address part of the set of management challenges, but multiple approaches may be necessary for holistic action. Deciding which intervention approaches to apply to a given problem context to address the complete set of challenges may be difficult. Furthermore, deciding how to combine multiple intervention approaches effectively complicates the problem. This paper describes the application method of a framework developed by Moore, Calvo-Amodio, and Junker (2015). The proposed framework and method will guide practitioners in holistically selecting and applying multiple intervention approaches to an experienced problem context without an extensive background in systems thinking.

**Soft Systems Methodology**

Soft Systems Methodology (SSM) was developed by Peter Checkland, who noticed that management science at the time was predominately based on ‘hard systems thinking’, structuring real-world scenarios as optimization problems based on goal-seeking. SSM is intended for use in complex scenarios lacking definition in structure and objective, where relationships of stakeholders are highly valued. This made it highly applicable to human activity systems, where people act to contribute to a purpose, such as organizations. In SSM such systems are viewed as loosely structured and dynamic with many perspectives to consider (Jackson, 2003). Figure 1 is a conceptual model of the SSM process.
SSM consists of seven stages. Stage 1 is simply identification of a situation to improve. Stage 2 involves creating a rich picture of the problem situation. A rich picture is an easily understood, pictorial representation of the system identified in Stage 1. In Stage 3, relevant human activity systems are selected, and root definitions are created for them. Root definitions of systems contain six elements, denoted by the acronym CATWOE: customer, actors, transformation, weltanschauung (world view), owner, and environment. A key element is weltanschauung (W), as each root definition has a different view of the situation of interest. Conceptual models are created for each root definition in Stage 4. A conceptual models consists of about seven activities necessary to achieve the transformation stated in the root definition. At Stage 5, the conceptual models are compared to the rich picture developed in Stage 2. The goal is to identify and discuss various weltanschauungen of the situation under study. In Stage 6, desirable and feasible changes are identified to act on the existing problem situation. Stage 7 is when the changes revealed in Stage 6 are acted upon. The expectation is that, upon acting on the problem situation, the real world will be modified and a new problem situation will emerge. This resets the SSM cycle. In this way, SSM is viewed as a never-ending intervention (Jackson, 2003). Figure 2 illustrates the seven steps of SSM.
This seven stage methodology has led to criticism, stating that SSM leads practitioners systematically more than systemically. There was also criticism that in practice, SSM is disconnected from the norms of organizations. In response to these claims, Checkland developed a modified SSM, which is referred to as the ‘two-strands’ version, which is meant to facilitate constant consideration of cultural in the problem context. There are three types of inquiry in the two-strands model: Analyses 1, 2, and 3. Analysis 1 is focused on the action to be taken and the roles of the actors: the client, problem-solver, and problem-owners. Analysis 2 examines roles, norms, and values in the problem situation. Analysis 3 considers the acquisition and use of power. These three Analyses are constantly revisited (Jackson, 2003).

SSM and other soft systems approaches have limited applicability. These approaches may be insufficient in cases where stakeholders have significant conflict or unequal influence, known in systems thinking as “coercive” contexts. Additionally, SSM requires commitment and much participation by practitioners (Jackson, 2003). For these reasons, coercive contexts and situations where practitioners are not well informed or not able to commit can be detrimental to the SSM process.

Some claim that SSM is isolated from other methodologies. Checkland does not discuss SSM in conjunction with other methodologies, nor does he use metaphors that are common in management science and organizational theory (Jackson, 2003).

SSM has also been criticised for simply modifying weltanschauungen, without considering the structures and foundations of them (Jackson, 2003).
System of Systems Methodologies

Jackson (2003) developed a framework for defining applied systems thinking strands, called the system of systems methodologies (SOSM). This framework describes problem contexts based on systemic complexity (the vertical axis) and the collaborative relationship between participants (the horizontal axis). Strands of applied systems thinking are defined in terms of problem contexts for which they are applied, based on the complexity and participant relationship.

Systemic complexity ranges from simple to complex. Complexity is driven by quantity of subsystems, and quantity and structure of interactions. Simple systems have few subsystems, and contain few and highly structured interactions. On the other hand, highly complex systems have many subsystems, and contain many loosely structured interactions. Additionally, simple systems are fairly static over time, whereas highly complex systems transform over time according to changes in their own parts and their dynamic environment (Jackson, 2003).

There are three types of participant relationships: unitary, pluralist, and coercive. A unitary relationship exists when participants share values, beliefs, and interests. Participants in a pluralist relationship will share interests, but have differing values and beliefs. Decision making in pluralist contexts depends on disagreement and conflict, leading to constructive debates. Compromise is attainable, even when all participants are active in decision making. Coercive participants will have varying interests and will not share values and beliefs. In coercive contexts, power is exercised to make decisions and compromise does not exist (Jackson, 2003).

Jackson (2003) later mapped applied systems thinking approaches on the SOSM. This modified model is valuable to show the assumptions made by systems approaches regarding problem contexts. The SOSM model with systems approaches is provided in Figure 3. According to the SOSM, the research being presented here is focused in the highlighted regions of Figure 3. This includes all pluralist problem contexts, and complex unitary contexts. Therefore, the systems approaches considered here are primarily soft systems approaches, which are commonly human systems such as organizations, and organizational cybernetics.
Critical systems thinking (CST) is an adaptation of systems thinking, intended to address complex problems with multiple differing viewpoints. These are the types of problems experienced in many organizations and other human systems. Total systems intervention (TSI) was developed as a methodology for applying CST in scenarios such as organizational management (Jackson, 2003).

Methodologies have strengths and weaknesses that can complement each other. They also have differing weltanschauungen, providing different perspectives of the problem context. TSI intends to make use of multiple systemic methodologies to address situations where a variety of perspectives are necessary for a holistic view. It aims to guide facilitators and participants to agreement about the major issues faced. Based on this agreement, systems methodologies are selected for intervention, with their strengths and weaknesses considered. The selected methodologies should be used in combination for intervention in corresponding aspects and contexts of organizations. It encourages constant reflection on the methodologies selected, as they may need reconsidering as the situation changes (Jackson, 2003).

The TSI methodology has three phases: creativity, choice, and implementation. The creativity phase is intended to reveal the primary concerns, issues, and problems in the situation. It is crucial that several viewpoints are used to achieve the outcome in this stage. The choice phase is when the intervention strategy is developed. Knowledge and information gained in the creativity phase, along with the strengths and weaknesses of methodologies considered, are used to determine a dominant and some dependent methodologies to be used for intervention. The final phase is implementation. At this point, the dominant methodology chosen will be used primarily to address the situation. Benefits offered by other methodologies should always be considered. Actors should repeatedly revisit the three phase cycle of TSI. It
is especially important to constantly question the choice of the dominant methodology and adjust this choice if necessary. This will be absolutely necessary if the problem situation changes (Jackson, 2003).

One weakness of TSI, as explained by Jackson (2003), is its commitment to pluralism, meaning it requires the use of methodologies as “wholes”. TSI requires that the dominant methodology be implemented as a whole, possibly blocking out dependent methodologies where the dominant methodology acts.

The usability of TSI has also been critiqued. Lack of instruction for navigating the three phases, especially creativity and choice, has been the source of some criticism. There have also been concerns surrounding the inconsistency of TSI with regards to its acceptance or rejection of alternate approaches. Others have claimed that TSI ignores environmental factors while focusing on considering perspectives of many stakeholders (Jackson, 2003).

TSI was developed to facilitate the use of multiple systemic methodologies (i.e., methodologies in the realm of systems thinking) to address complex problem contexts. However, methodologies that are not “systemic”, or in the field of systems thinking, may have much to offer certain problem contexts.

**Creative Design of Methods**

Midgley (as cited in Midgley, Munlo, & Brown, 1998, p. 306) developed a concept called creative design of methods (CDM) based on the TSI concept that simply choosing a single methodology for intervention may be insufficient in complex problem contexts. As Jackson (2003) explained with regards to TSI, a variety of perspectives are necessary for a holistic view of complex problem situations.

Midgley, Munlo, and Brown (1998) emphasized that CDM synthesizes multiple methodologies to create a single intervention method. It combines methodologies to create a new method that is more valuable than the individual methodologies in the problem context. TSI encourages the use of methodologies in their complete and pure form with dominant and dependent methodologies identified. CDM uses pieces of methodologies as they apply to the problem context to create a custom intervention method.

Generation of a CDM intervention method is driven by a series of systematically interrelated research questions developed based on the desired outcome. Boyd et al. (2007) noted that the purpose of intervention, which drives the research questions, may change as the analysis develops. A methodology to address each of the research questions is chosen. The selected methodologies are synthesized to create an appropriate intervention method. The means of developing these research questions and designing the resulting method is not well defined, but Midgley, Munlo, and Brown (1998) stated that intuition and deliberation may be tools used for decision making.
Boundary Critique

Boundary critique was developed by the work of Ulrich and Midgley, based on previous work by Churchman. It is a discipline of critical systems thinking which explores alternate boundaries of analysis and how adjusting the boundaries affects intervention, while maintaining critical awareness. Critical awareness means constantly considering assumptions and their basis (Midgley, Munlo, & Brown, 1998).

Churchman (as cited in Midgley, Munlo, & Brown, 1998, p. 467-468) determined that the boundary of a system under analysis is an important consideration. He expresses that boundaries are created, not given. He believes that wider boundaries may deem some improvements insignificant; therefore, he encourages definitions of improvement which contain as much information as possible. Churchman supports widening of boundaries, including several differing perspectives, referred to as ‘rolling out’ the boundaries. Widening of boundaries may affect who is considered a decision maker. He asserts that practitioners should consider the perspectives of the strongest possible enemies. Improvement attempts should only be continued if robust arguments against enemies exist.

Ulrich (as cited in Midgley, Munlo, & Brown, 1998, p. 468) created a methodology called critical systems heuristics to appropriately select boundaries using stakeholder collaboration. Ulrich believes that Churchman’s desire to include as much information as possible into improvement definitions is limited by the need for practical solutions. Ulrich maintains that all assumptions should be subject to questioning. To ensure improvements are ethically sound, Ulrich explains that an agreement must be met between the designers and those affected by proposed actions.

Midgley (as cited in Midgley, Munlo, & Brown, 1998, p. 469) examined situations where stakeholders disagree about the boundaries of a system. When conflicting boundary definitions exist, one is narrower and one is wider, these are assigned as the primary and secondary boundaries, respectively. The area in between the defined boundaries, included in the secondary boundary but not in the primary boundary, is said to be marginalized. To resolve boundary conflicts, the marginalized area is deemed either sacred or profane. When the marginalized area is profane, the primary boundary is given priority in decision making. This means that the marginalized area and secondary boundary are not considered. When the marginalized area is sacred, everything within the secondary boundary, including the marginalized area, is considered in decision making. However, Midgley emphasized that those making boundary judgements must not neglect what is contained in the marginalized region when a profane status is imposed. Figure 4 illustrates a marginalized region between a primary and secondary boundary.
In practice, boundary critique is executed in two phases. Phase 1 is Identifying Problems. In this phase, stakeholders are identified to be interviewed. One technique to develop the richest understanding of the problem context is starting with stakeholders that are easy to identify, then asking them to name others that should be interviewed. This was developed by Midgley and Milne (as cited in Midgley, Munlo, & Brown, 1998, p. 471) to ‘roll out’ the boundaries of analysis. After Phase 1, it is beneficial to review the work done to ensure that marginalized entities are not being treated as profane prematurely. To prepare for Phase 2, Designing Improvements, a workshop is held to develop an intervention plan with key stakeholders within the relevant boundary. To guide intervention, stakeholders are encouraged to imagine an ideal scenario, ‘ideal’ meaning ‘best possible’ but reasonable technologically and organizationally. Midgley, Munlo, and Brown (1998) describe a case study in which the problem solving team devised a plan to synthesize three methodologies to approach the ideal state.

Boundary critique and CDM were derived from TSI, and have become pivotal tools in TSI practice. Midgley (1998) claimed that CDM is practically necessary in conjunction with TSI. CDM provides more definition in selecting methodologies for intervention by using research questions to guide the decision. Boyd et al. (2007) recognized that boundary critique is necessary in the early stages of CDM to ensure that the problem situation is fully understood. In this way, boundaries affect which intervention approach to use as CDM uses the understanding of the problem context to select intervention approaches. Some intervention approaches have weltanschauungen that encompass only the organization itself, whereas others include the environment surrounding the organization.

TSI, CDM, and boundary critique have inspired the framework and method proposed here. TSI provided the foundational concept of combining methodologies to match a
complex problem context. It outlines a three phase process of understanding the problem context, choosing methodologies to implement, and implementing the methodologies. The proposed method follows the same process. However, TSI requires pluralist implementation of methodologies; CDM allows the use of elements of methodologies to create a new method. The CDM practice of synthesizing methodologies based on a set of research questions about the problem context inspired the situation definition stage of the proposed method. In choosing methodologies, TSI presented the idea to assign dominant and dependent methodologies, ranking them primary, secondary, tertiary, and so on. This is used in the proposed method to design a complementarist approach. Boundary critique is used in implementation to guide the complementarist intervention. The practitioner must consider the boundaries of individual intervention approaches to assign sacred or profane status to the marginalized space when boundaries do not align. This allows dependent approaches to compliment implementation of the dominant approach.

**Intervention Approach Definition and Application Framework**

Moore, Calvo-Amadio, & Junker (2015) have created a framework for intervention approach definition and application. More detail on the development of this framework is available in (Moore, Calvo-Amadio, & Junker, 2015). The primary contribution of this framework is prescribing intervention approaches to fit a given problem context. Intervention approaches are mapped on the framework based on the problem contexts they are intended to act in. This is driven by the weltanschauung of an approach.

**Four Definition Categories**

The proposed framework defines problem contexts by four categories: Scope, Inspiration, Solution, and Ideal. Each of these categories ranges between two extremes. The categories are described in detail below. Each of the four categories is an axis on the framework, describing a component of the problem context of interest.

*Scope*

Scope defines whether the intervention is primarily functional or structural. This axis ranges between the two extremes “organizational operations” and “organizational design”.

*Inspiration*

Inspiration expresses what drives the intervention. The extremes of this category are “resource (internally) driven” and “context (environmentally) driven”.

*Solution*

Solution describes how the intervention views its objective. One extreme is goal-seeking, striving for “optimal amount of resources”, the other extreme simply settles for “right/ adequate amount of resources”.
*Ideal*

Ideal explains what an intervention approach values. It ranges from “organizational culture” to “organizational control”.

Some intervention approaches may have a strong preference for extremes on the four axes, these approaches will populate the corners of the framework. Other approaches may be somewhat indifferent in the categories, leading them to populate the centre of the framework.

**Beneficiary Line**

A diagonal line is draw across the framework. This line divides the framework based on the primary beneficiary of improvement action in a problem context. The two primary beneficiaries are workers and management. When workers are the primary beneficiaries, organizational operations and culture are likely affected. When management is the primary beneficiary, organizational design and control are likely improved.

The beneficiary regions in the framework are progressive rather than definite. This means that as problem contexts shift away from the dividing diagonal line (toward the upper-left or lower-right), the magnitude of benefit toward one party (workers or management) is stronger.

The proposed framework, including the four axes and beneficiary line is provided in Figure 5.
Figure 5. Intervention Approach Definition and Application Framework (Moore, Calvo-Amodio, & Junker, 2015)

**Intervention Approach Definition**

For the framework to serve its primary purpose, intervention approaches must be defined within it. Each approach will be defined based on the problem context, and associated weltanschauung, it was designed for. These approaches will populate regions within the graph, demonstrating the problem contexts for which they are most suitable for.

**Application Method**

**Epistemology vs. Ontology of the Method**

Epistemologically, the proposed method follows a similar pluralistic approach to TSI. That is, several intervention approaches are synthesized as wholes to design a single new intervention approach with a unified weltanschauung. In the language of boundary critique, this would require sacred status of the marginal space between the boundaries of the approaches applied. However, as Jackson (2003) has revealed, conflict may exist when pluralism of multiple approaches is desired.
Jackson (2003) explains that an intervention approach is designed with methods to achieve certain outcomes, based on a particular weltanschauung of the problem context experienced. Moore, Calvo-Amodio, and Junker (2015) discuss utilizing elements from multiple intervention approaches to act in an experienced problem context. This perspective realizes that an intervention approach often has value outside of the weltanschauung and problem context for which it was designed. Conceptually, this is similar to SSM. SSM was designed to combine weltanschauungen of multiple stakeholders in an organization to create a shared weltanschauung, driving desirable and feasible change to the problem context (Checkland, 2000; Jackson, 2003). The proposed method combines weltanschauungen of multiple intervention approaches, rather than stakeholders, to create a unified approach to act in a problem context with the desired weltanschauung. This may be necessary when holistic intervention is desired, where no single intervention approach addressed the challenges faced. Several intervention approaches combined may provide the tools necessary to beneficially impact a complex problem context. Although weltanschauungen of multiple intervention approaches may not align, elements from each may be extracted to act in the existing problem context.

Ontologically, this is a complementarist method, meaning that a dominant approach is used with others to compliment it. In TSI, this has been suggested as a realistic alternative to pluralism. The dependent approaches complement the dominant approach. The dominant approach may be applied as a whole, but parts of the dependent approaches must be compromised. The marginal space between the boundaries of dominant and dependent approaches must be considered profane. In this way, a dominant approach is selected and beneficial elements from dependent approaches are utilized.

As previously discussed, CDM involves selecting several approaches for intervention based on research questions developed for the intervention purpose. The proposed method provides a structured method for selecting intervention approaches based on the problem context. In this way, the proposed method may aid those who wish to use CDM, which according to Midgley (1998) is necessary for application of TSI.

**Defining a Problem Context**

The intervention definition and application model can be used to map intervention approaches and problem contexts. Having already mapped intervention approaches, practitioners can map their experienced problem contexts to determine which approaches coincide with the problem context, thus are applicable. To map a problem context, a practitioner will have to make judgements regarding the problem context.

A practitioner will have to analyse the experienced problem context in each of the four categories previously discussed: Scope, Inspiration, Solution, and Ideal. Each of these categories has a scale ranging between two extremes. To make the analysis quantifiably-based, two-directional 0 to 5 scales are displayed on each of the four axes. This is shown on the framework in Figure 6. Zero is at the centre of each axis,
representing a neutral position. Each axis has two 5 values, one for each extreme on a given axis. During the following analysis, each “extreme” of each axis will be assigned a number ranging from 0 to 5, representing how strongly valued the “extreme” is in the problem context. The strongest value for an “extreme” is expressed by assigning a 5. Conversely, assigning a 0 to an “extreme” demonstrates minimal value in the problem context.

Figure 6. Intervention Approach Definition and Application Framework with Axis Scales

A quantification questionnaire is used to capture the value of each “extreme” for each axis. The questionnaire contains a scale for each of the four categories. For each category a numbered scale of 0 to 5 in two directions is provided. On the scale is a shaded box with a length of five units on the scale. This shaded box represents the area of value on the scale. A practitioner moves the shaded box toward one extreme or the other to demonstrate preference of one over the other, and the strength of that preference. The scale numbers on each edge of the shaded box are the values assigned to the associated extreme. The strongest expression of preference is shown by the box placed all the way to one extreme, thus assigning a value of 5 to one extreme and 0 to the opposite extreme.
Research questions may aid the practitioner in assigning values in each of the four categories. This concept is borrowed from CDM, where research questions are used to establish the purpose of intervention, and thus guiding the selection of intervention approaches. These questions may also add clarity to what each category, and the associated extremes, entails. Research questions for each category are provided below.

**Scope**
- Is the problem context an issue of generating work products (i.e., operations), or is it a consequence of organizational structure (i.e., design)?

**Inspiration**
- Is the problem context primarily concerning organizational resources, or does it involve the external environment (i.e., context)?

**Solution**
- In the problem context, is it necessary to seek a specific goal (i.e., optimize) with one correct solution, or can it be satisfied with an adequate solution? (An adequate solution implies that there are multiple correct answers or that the goal is not well defined.)

**Ideal**
- Will the problem context be most affected by shifts in organizational culture, or modifications in organizational control?

A model of the quantification questionnaire is provided in Figure 7. The shaded box positions shown are arbitrary, placed to demonstrate the most neutrality possible in each category.
It should be noted that the questionnaire design forces certain outcomes to occur. Firstly, the sum of the values assigned to each extreme is five for each category. Possible combinations and their associated summations are provided in Table 1.

Table 1. Possible Values Assigned to Two Extremes on One Axis

<table>
<thead>
<tr>
<th>Extreme 1 Value</th>
<th>Extreme 2 Value</th>
<th>Value Addition</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5</td>
<td>0 + 5 = 5</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>1 + 4 = 5</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>2 + 3 = 5</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>3 + 2 = 5</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>4 + 1 = 5</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>5 + 0 = 5</td>
</tr>
</tbody>
</table>
Another consequence of this design is that the practitioner must express preference for one of the two extremes in each category. This is due to the selection of a maximum value that is an odd number. Even the most neutral result, 2 and 3 or 3 and 2, shows a slight preference for one extreme. This allows practitioners to have dual consideration between extremes if desired, but forces determination of a preference.

After each “extreme” is assigned a value, the problem context may be defined within the framework. Use of the shaded box with a length of five units ensures that, once mapped on the framework, a problem context will be represented by a four-sided shape with all sides having length of five units.

Creating shapes within the framework is simplified by considering only two “extremes” at a time. To begin, one should pick a corner of the square framework. Each corner contains two “extremes”. The value for the two extremes in the selected corner should be determined based on the previously established ratings on the quantification questionnaire. The point on the framework where the values of the two “extremes” intersect is plotted. This is one corner of the shape that is being constructed. The process of selecting a corner, determining values for the two “extremes” in that corner, and plotting the resulting point should be repeated for all four corners of the framework.

**Selecting Intervention Approaches**

The shape defining the problem context in the framework will intersect at least one shape representing an intervention approach. Whichever intervention approach shape shares the most area with the problem context shape will be chosen as the dominant, or primary, intervention approach.

If the problem context shape intersects multiple intervention approach shapes, dependent approaches may be identified to complement the dominant approach. Having selected the approach with the greatest shared space with the problem context as dominant (primary), the approach with the second largest shared space will be the secondary. The intervention approach shape that shares the third largest space with the problem context shape will be the tertiary approach.

Given the range of values on the framework axes and the forced size of the problem context shapes, at least one intervention approach shape will be intersected. This ensures that at least one intervention approach is identified for any problem context. Although multiple approaches are likely necessary to holistically act in complex problem contexts (Jackson, 2003).

The method described so far in this section assumes that the practitioner has not already selected intervention approaches to apply. In this case, the framework will likely be able to prescribe approaches that best match the problem context. However, practitioners may have a predetermined intervention approach, or set of approaches, that are desired. This is true in the case study provided on the following pages. When
intervention approaches are already selected, the framework is beneficial to establish the order of dominant and dependent approaches, including assigning dependent approaches as secondary and tertiary. When a problem context is mapped on the framework, it may not intersect at all with a pre-selected intervention approach on the framework. This likely means that the intervention approach was not designed for similar problem contexts similar to the one experienced, but it may still have beneficial elements. It would likely not be beneficial to assign dominant status to an intervention approach that does not overlap the problem context. Instead, the method described above for assigning dominant and dependent approaches should be used, with intervention approaches that do not overlap the problem context given the lowest ranking. The approach that is closest to the problem context should be assigned higher priority compared to one that is farther away.

The proposed method can be viewed as providing support to the three phase process of TSI. As Jackson (2003) has noted, some criticize TSI for lacking structure in its three phases, especially in the creativity and choice phases. The proposed method facilitates the creativity phase as it defines intervention approaches and the problem context on the same framework. Practitioners may discover new and beneficial intervention approaches to apply simply by viewing the framework, which will be populated with existing intervention approaches.

The choice phase of TSI is completed when intervention approaches are assigned priorities based on their position on the framework relative to the problem context. As in TSI, there are two sets of approaches: dominant and dependent. The dominant approach is primary, and dependent approaches are secondary and tertiary.

Applying Intervention Approaches

The final stage of both TSI and the method proposed here is implementation. The proposed method is similar at this point to the implementation phase of TSI. As Jackson (2003) has suggested, many consider this to be the best-defined phase of TSI.

Consistent with the third phase of TSI, implementation of the proposed method will give highest priority to the dominant approach while utilizing beneficial elements of dependent approaches. When considering an action in the problem context, intervention designers should first consider how the dominant intervention approach views the situation. In this way, the weltanschauung of the dominant approach will have the most leverage in the intervention. If the dominant approach does not consider, or is indifferent toward, the action considered, the secondary approach should be consulted for guidance. Furthermore, if the secondary approach is not able to guide intervention, the tertiary approach should be applied. In this way, intervention is driven by the primary approach, while utilizing beneficial elements of the secondary and tertiary approaches.

When seeking guidance from intervention approaches in pairwise fashion, the theories of boundary critique are applicable. To keep the language consistent from the earlier discussion of boundary critique, consider two intervention approaches,
primary and secondary, each with its own weltanschauung. Each intervention approach has a boundary for its theory, determined by its weltanschauung. Since these two approaches do not agree on a single boundary, there is a marginalized space. The marginalized space will, by default, be considered profane. When the primary boundary is not wide enough to serve the desires of the practitioner in the problem context, the boundary must be expanded. This is achieved by deeming the marginalized space sacred, widening the boundary of analysis to that of the secondary approach. This allows the secondary approach to guide actions that exist in the marginalized space. The same holds true when considering the secondary and tertiary approaches, if this is appropriate for the problem context.

As TSI teaches, it is important to remain critical of intervention approaches selected, especially the dominant approach. As action is taken in the real world, the problem context shifts and the proposed analysis method should be reiterated. This is also true if the practitioner desires to act in a new problem context. A different set of intervention approaches may be necessary for a modified or new problem context.

**Case Study**

**Background**

The Oregon State University (OSU) Energy Efficiency Center (EEC) is a small, non-profit service organization performing knowledge-based project work in a dynamic environment. The EEC has a multi-faceted mission, benefitting assessed facilities, OSU students, OSU, industrial partners, and the public (OSU Energy Efficiency Center, n.d.). This creates a vast and diverse set of stakeholders. Further definition of this case is provided by Moore, Calvo-Amodio, and Junker (2015).

**Management Challenges**

The nature of the EEC and its environment lead to several management challenges, including development of a non-central management structure, retention of knowledge in a rapid turnover environment, and meeting diverse stakeholder demands.

**Management Structure**

The EEC has recently developed a management structure that delegates management roles and tasks to a larger set of individuals, as opposed to the director and operations managers being responsible for all. The organization has already benefitted from this management structure modification, but further consideration would likely be advantageous.

**Knowledge Utilization**

Analyst-workers at the EEC generally start their tenure with little to no relevant experience aside from university coursework. A crucial function of the EEC is developing the skills of analysts. This increases their value to the organization and later in their careers.
The work performed at the EEC requires specialized knowledge that is developed through experience. Knowledge retention is a challenge at the EEC because of the training and skills required and short employee tenures, averaging about two years.

The EEC uses many electronic resources. These resources are currently spread across several media, some being poorly organized. Distribution, application, and development of knowledge would likely be improved with better organization and definition of electronic resources.

**Complex Operations and Stakeholder Requirements**
Preparing the primary deliverables of the EEC, assessment reports, is a complex process. It consists of many loosely defined operations that are dependent on each other. An assessment report is the product of a combined effort of several analysts. Constraints exist in terms of quality, completion time, and cost of assessment reports. Furthermore, analysts are constrained in the amount of time available to work on their contributions to the reports. All these factors make report generation a complex operation.

**Selected Intervention Approaches**
Based on the previously discussed set of management challenges at the EEC, three intervention approaches have been deemed suitable by Moore, Calvo-Amodio, and Junker (2015). The three approaches to be applied to the EEC are viable system model (VSM), knowledge management (KM), and Toyota production system (TPS), also known as lean manufacturing.

**Viable System Model**
VSM is a systems thinking methodology developed by Stafford Beer based on organizational cybernetics, which focus on control of, and communication within, organizations. VSM defines what makes an organization viable, meaning capable of existence independently of other entities in its environment. According to VSM, particular roles and interactions must exist for an organization to remain viable (Beer, 1984).

The law of requisite variety is a crucial component of VSM. This theory states that an organization must contain enough variety to address any state of its environment, facing any challenge posed (Beer, 1981; Beer, 1984). One method to reduce variety in an organization’s environment is creating a non-centralized management structure (Beer, 1981).

VSM will be used at the EEC to guide its management structure, including creating non-centralized management.

**Knowledge Management**
The EEC performs knowledge-based work (Moore, Calvo-Amodio, & Junker, 2015). Therefore knowledge is a crucial resource at the EEC. KM is concerned with maximum utilization of knowledge within and generated by an organization.
(Davenport & Prusak, 1998). It can also be applied to exploit knowledge form an organization’s environment (Grant, 1996). The KM process consists of effectively: collecting, retaining, distributing, and applying knowledge in an organization. A primary theme of KM is converting tacit knowledge, that which is contained in and individual, to explicit knowledge, which is shared (Nonaka, 1991; Nonaka, Umemoto, & Senoo, 1996).

Knowledge is developed over time, as an employee gains experience (Davenport & Prusak, 1998; Levy, 1965; Nonaka & Takeuchi, 1995). There is a risk of losing knowledge when employees leave an organization if efforts are not made to retain it (Fong & Kwok, 2009). Given that the EEC has rapid employee turnover, there are frequent possibilities of losing knowledge, making knowledge retention efforts crucial.

KM will be used at the EEC to gather, share, and retain knowledge from inside the organization and its environment.

*Toyota Production System*

TPS was developed for application in automobile manufacturing, but has more recently been applied to benefit service organizations (Lander & Liker, 2007). TPS is a methodology primarily concerned with simultaneous value delivery and cost reduction by seeking to eliminate waste in operations (Monden, 1983).

TPS will be beneficial at the EEC to ensure value delivery to stakeholders with minimal waste.

**Framework Application**

All three intervention approaches (VSM, KM, and TPS) address part of the set of management challenges faced at the EEC. However, no single approach will address the whole set of challenges. Therefore, a complementarist approach is desired. The proposed framework is well suited to guide interventions in problem contexts encountered at the EEC. As problem contexts arise, managers can use the proposed framework and method to guide intervention actions. In this case VSM, KM, and TPS will be the set of pre-selected intervention approaches; therefore the decision is which is primary, secondary, and tertiary in different contexts.

To prepare for application, the three selected intervention approaches were mapped on the proposed framework. The method used to map the intervention approaches is identical to the method described earlier. The difference was that an intervention approach was being defined, rather than a problem context. The values assigned to all extremes are provided in Table 2.
Table 2. Summary of Quantification Questionnaire for Case Study Intervention
Approach Definition

<table>
<thead>
<tr>
<th>Scope</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organizational Operations</td>
<td>VSM</td>
<td></td>
<td></td>
<td>KM</td>
<td>TPS</td>
<td></td>
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<tr>
<td>Organizational Design</td>
<td>TPS</td>
<td>KM</td>
<td></td>
<td></td>
<td>VSM</td>
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</table>

**Inspiration**

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<tr>
<th></th>
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<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resource (Internally) Driven</td>
<td>VSM</td>
<td></td>
<td></td>
<td>KM/TPS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Context (Externally) Driven</td>
<td>KM/TPS</td>
<td></td>
<td></td>
<td>VSM</td>
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<td></td>
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</table>

**Solution**

<table>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimal Amount of Resources</td>
<td>VSM</td>
<td></td>
<td></td>
<td>KM/TPS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right/ Adequate Amount of Resources</td>
<td>KM/TPS</td>
<td></td>
<td></td>
<td>VSM</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Ideal**

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organizational Culture</td>
<td>VSM</td>
<td></td>
<td></td>
<td>KM</td>
<td>TPS</td>
<td></td>
</tr>
<tr>
<td>Organizational Control</td>
<td>TPS</td>
<td>KM</td>
<td></td>
<td></td>
<td>VSM</td>
<td></td>
</tr>
</tbody>
</table>

Definition of VSM, KM, and TPS as regions on the proposed framework is shown in Figure 8.
The next step for the EEC to apply the proposed method is to define a problem context in the framework. Upon framework definition, the three intervention approaches will be assigned priority rankings based on the position of the problem context in the framework. This will assist managers in developing actions in real world scenarios.

As an example, Figure 9 is a diagram of VSM with indications of how KM and TPS can be used within it.

Figure 8. Intervention Approach Definition and Application Framework containing VSM, KM, and TPS
Figure 9 represents a case where VSM is selected as the dominant, or primary, approach. Therefore, KM and TPS are dependent approaches. VSM, being the dominant approach provides the organizational structure. VSM does not define communication channels within the organization or with the environment; it only states that they are vital (Beer, 1984). KM can support these communication channels. Additionally, operational elements of the subsystems within VSM are not defined other than descriptions of their roles and interactions. There are no guidelines or tools for these subsystems to effectively operate. TPS can aim in ensuring that these subsystems are achieving their goals efficiently.

Without KM and TPS, VSM may have seemed like an incomplete intervention approach. Synthesizing all three creates a holistic approach to address the set of management challenges at the EEC.

**Limitations**

The proposed framework and method has some limitations. One limitation is that it currently forces shapes constructed on the framework to be four sided figures with side lengths of five units. This was a design choice to keep the preliminary framework and method simple, but in the future it would likely be beneficial to all
more freedom in the shapes of problem context and intervention approach regions on the framework.

Additionally, users would likely benefit from more definition in selecting values on the quantification questionnaire. The current translation of a real-world problem context into quantities in the questionnaire is subjective.

Definition of problem contexts and intervention approaches are currently based on practitioner judgement, assumedly expert opinion. In the future, definition of intervention approaches in the framework should be established, gaining consensus by several experts. An additional method to create a shared view and understanding of problem contexts would be beneficial. Such a method could make use of a methodology such as SSM.

Lastly, additional support in selecting intervention approaches would be useful. Such support may suggest how many intervention approaches should be applied. It would likely also be beneficial to make more quantifiable guidelines for selecting approaches. For example, instead of depending instructions such as “select the approach that overlaps the most”, calculating the area of the shared space would allow users to objectively make decisions. This would define how to select the dominant approach. The dominant approach would be the approach that has the most shared area with the problem context. Then the secondary approach would have the second most shared area and so on.

**Conclusions and Future Work**

Moore, Calvo-Amodio, and Junker (2015) created a framework for defining and selecting intervention approaches. This tool defines problem contexts based on four categories: Scope, Inspiration, Solution, and Ideal, each ranging between two extremes. It also identifies which party benefits most from improving the existing situation: workers or management. Intervention approaches are modelled as regions on the framework, representing the problem context that they were designed for, and thus are strongest in. Practitioners may map their experienced problem context on the framework, which will also be modelled as a region. Overlapping of an intervention approach and a problem context on the framework shows that the intervention approach is well-suited for implementation in the problem context.

This paper presents a method for applying the framework developed by Moore, Calvo-Amodio, and Junker (2015). The proposed method is based on foundations set by TSI, CDM, and boundary critique. The method guides practitioners in translating an experienced problem context into a region on the framework using a quantification questionnaire and numeric axes on the framework. Intervention approaches will be mapped on the framework, filling regions of their own. Practitioners will select intervention approaches to apply to a situation based on proximity of the problem context shape and intervention approach shapes on the framework, with priority given to those that overlap. The dominant intervention approach will be used primarily in
implementation, with support of dependent approaches were the dominant approach is not defined.

The proposed framework and method will allow managers to benefit from the use of systems thinking without having a background in it. It will guide managers to select interventions approaches to match their problem contexts and design complementarist approaches.

Future work should address the limitations discussed. The framework should be populated with as many intervention approaches as possible. The proposed framework provides an opportunity for a computer application, guiding users through the method.

As discussed in the Limitations section, further quantification and definition in selecting dominant and dependent intervention approaches is necessary. The proposed method relies on the user’s interpretation of the shapes representing problem contexts and intervention approaches on the framework. A computer application would likely be very helpful in incorporating such improvements.

The proposed framework and method will be applied at the EEC and validated for use in similar organizations, with opportunities for application in other organizations explored.

REFERENCES


Chapter 6

6 Findings, Conclusions and Future Work

6.1 General findings

Intervention approaches are developed to intervene in a given problem context, and are composed of commensurable methods to achieve particular purposes. These factors contribute to an intervention approach’s weltanschauung (Jackson, 2003). As a result, different intervention approaches have differing weltanschauungen. This was demonstrated with the CATWOE literature review of VSM, KM, and TPS. These approaches were applied in similar environments, with similar stakeholders, but had differing transformations and weltanschauungen. This realization inspired the development of a framework to define intervention approaches and problem contexts.

Based on the differing transformations and weltanschauungen from the literature review, four categories of problem context definition were generated: scope, inspiration, solution, and ideal. These can be used to catalogue a problem context and assist designing intervention approaches. Intervention approaches and problem contexts are mapped as regions on the proposed framework. When regions of intervention approaches and problem contexts overlap in the framework, applicability of the approach to the context is suggested.

SSM, TSI, CDM, and boundary critique are methodologies for combining methodologies, or intervention approaches. These all require a working knowledge of systems thinking for application. Furthermore, TSI, CDM, and boundary critique are primarily theoretical, with little practical insight. A method based on these four existing methodologies, tailored for the proposed framework is needed.

6.2 Conclusions

VSM, KM, and TPS have differing weltanschauungen and methods of intervention, but they are applied in similar cases based on CATWOE of previous applications.
This, combined with theoretical connections, demonstrates that the three are compatible with each other and may be combined for a holistic intervention. Future work will develop a methodology for applying a synthesized model that consists of VSM, KM, and TPS for problem contexts similar to those of the EEC.

The need has been identified for a model to guide management interventions. Support for managers is needed to select and apply appropriate intervention approaches for given problem contexts. A framework was proposed to define and select intervention approaches for application in different problem contexts. This tool defines problem contexts based on four categories: Scope, Inspiration, Solution, and Ideal, each ranging between two extremes. It also identifies which party benefits most from improving the existing situation: workers or management. Intervention approaches are modelled as regions on the framework, representing the problem context that they were designed for, and thus are strongest in. Practitioners may map their experienced problem context on the framework, which will also be modelled as a region. Overlapping of an intervention approach and a problem context on the framework shows that the intervention approach is well-suited for implementation in the problem context. This framework can be used as a guide for practitioners to either select an approach for intervention, or to establish precedence of multiple approaches if a complementarist approach is desired. The primary contribution of this project is the intervention approach and problem context definition model, which is shown in Figure 12.
The proposed method is based on foundations set by TSI, CDM, and boundary critique. The method guides practitioners in translating an experienced problem context into a region on the framework using a quantification questionnaire and numeric axes on the framework. Intervention approaches will be mapped on the framework, filling regions of their own. Practitioners will select intervention approaches to apply to a situation based on proximity of the problem context shape and intervention approach shapes on the framework, with priority given to those that overlap. The dominant intervention approach will be used primarily in implementation, with support of dependent approaches were the dominant approach is not defined.

The proposed framework and method will allow managers to benefit from the use of systems thinking without having a background in it. It will guide managers to select...
interventions approaches to match their problem contexts and design complementarist approaches.

6.3 Future Work

6.3.1 Apply Proposed Framework and Method in Case Study

The proposed framework and method were developed using the EEC as the research subject. Due to time constraints of the project, the framework and method were not applied. The EEC would likely benefit from the outcomes of this research. Future work should validate the framework and method for use at the EEC and similar organizations. Then application to other organizations should be explored.

6.3.2 Populate Framework with Several Intervention Approaches

The framework may be used by practitioners to discover intervention approaches that would be beneficial in an experienced problem context. To maximize its value as a discovery tool, as many approaches as possible should be defined within the framework. Currently, only VSM, KM, and TPS are included in the framework as these have been chosen to address the management challenges at the EEC, which may match management challenges at similar organizations (small non-profit, service organizations performing knowledge-based work in a dynamic environment). As opportunities to apply this framework to other types of organizations are explored, more intervention approaches will likely be necessary.

Additionally, the definition of approaches in the framework should be confirmed and standardized. Currently, placement of approaches is based on expert opinion.

6.3.3 Develop Quantification to Allow Differing Shapes on Framework

Currently, the quantification questionnaire forces shapes with all sides of equal length (five units) on the framework. This was a design decision to create a simple preliminary design. Shapes representing intervention approaches and problem contexts may be more accurate if more freedom in shape form is granted. This will
add complexity to defining approaches and contexts, but will make the framework more flexible and accurate. A further explanation of the consequences of the current design decision is conducted in section 2.3.2.3.

6.3.4 Develop More Structured, Quantifiable Method of Selecting Approaches

It would likely be beneficial to make more quantifiable guidelines for selecting approaches. For example, instead of depending instructions such as “select the approach that overlaps the most on the framework”, calculating the area of the shared space would allow users to objectively make decisions. This would define how to select the dominant approach. The dominant approach would be the approach that has the most shared area with the problem context. Then the secondary approach would have the second most shared area and so on.

Additionally, a proper test should be conducted for the accuracy of placing intervention approaches on the framework using the quantification questionnaire. The current research included only a preliminary assessment, checking the consistency of intuitive assumptions against the use of the questionnaire. In this assessment, one expert was used for both methods.

6.3.5 Create a Computer Program for Proposed Framework and Method

The proposed framework and method presents an opportunity for a computer application. Intervention approaches would be previously defined in the program, allowing the user to select some ahead of time or requiring the program to select the most appropriate approaches. The quantification questionnaire for a problem context would be completed in the computer application with a user interface. Based on the user input, the program will prescribe intervention approaches and the priority ranking of each (i.e., primary, secondary, tertiary, etc.). The application could even provide background information and guidance for how to apply individual intervention approaches according to the prescribed intervention.
7 References


Figure A1. Diagram of viable system model (based on Beer, 1984)