The Influences of Learning Behavior on the Performance of Work Teams -
A System Dynamics Approach

by

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ABSTRACT

This thesis seeks to apply the tools of system dynamics to the study of the influences of
learning-oriented behaviors on team performance and to investigate what factors foster team
learning in the organizational environment and what factors hinder it. To address this issue, I
examine existing works in the organizational learning field, including a thoughtful,
descriptive model of team learning developed by Amy Edmondson of the Harvard Business
School. Her model focuses on psychological safety -- a shared belief held by team members
that the team is safe for interpersonal risk-taking -- as a construct that facilitates learning
behavior, which in turn influences team performance.

Drawing on Edmondson's team learning model and on textual analysis, I develop causal
loop diagrams to capture endogenous processes which, theorists argue, influence team
learning and promote performance. Using Edmondson's descriptive model as a starting
point, I develop a formal simulation model to understand the dynamics created by learning
initiatives. I describe the formulation in detail, relating the simulation model to Edmondson's
model and to supporting theories on organizational learning, mainly to those developed by
Chris Argyris, Edgar Schein and Peter Senge.

Simulation tests are carried out to address the question: What are the factors that promote a
team's engagement in learning behavior? The simulation results show three factors that play
a critical role in fostering team learning and promoting performance (1) less aggressive
performance goals; (2) a minimum level of psychological safety; and (3) a high level of
team self-confidence. Understanding such factors and their effects is of use to academics
developing theories of organizational learning and to managers trying to implement or
review learning initiatives.

Thesis Supervisor: Peter Senge
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A Word from the Author

When I first visited the Boston area in the summer of 1995, I thoroughly researched Harvard and MIT environments. Many things fostered my interest in pursuing my MBA education in this very rich academic area. Although the high quality of education and the respectability of Harvard around the world are unquestionable, many factors led me to decide to apply only to MIT. MIT is not only a leading research institution in Organizational Learning, System Dynamics, Technology, Economics and in many other fields of knowledge, but it has a more informal multicultural environment with open door policy, very hardworking people, and small classes. This was a must for me who wanted to get a world class education and to understand the deepest nature and the trends of our fast changing times.

In the Fall of 1997, I began my MBA at MIT. Within this rich incubator of ideas and successful startups, I initially decided to diversify my academic experience by studying subjects such as Technology, Entrepreneurship, Finance and Economics. Later, I decided to concentrate my academic interests in Organizational Learning and System Dynamics. To enrich my academic experience, I decided to stay one more semester in Boston to write a thesis in both of my concentration fields of study and to take some interesting courses at Harvard Business School, while, as an insider, having the opportunity to have a finer perception of its very rich environment.

In this whole exciting, challenging and eventually very rewarding experience, the accomplishment of my thesis work crowns a five-year educational cycle of my life. Besides achieving my initial planned goals, I also acquired a world class mindset that helps me to have an international perspective of global and local realities, and become a much better professional and citizen.

Elaine Lizeo
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Chapter One

Introduction

An increasingly competitive global economy combined with fast changes in technology has led organizations to seek more flexible and flatter organizational structures and better business practices and processes. We are living in a world in which competitive advantage depends on generating and sharing knowledge and on managing interdependencies and change (Thomas Malone et al, 1999). As existing knowledge and skills become obsolete, the need for organizations and individuals to continually learn and improve increases. The organization's ability to learn has been viewed as a source of competitive advantage (de Geus, 1988). Many organizations have embraced the goal of becoming a "learning organization" to succeed or survive in competitive environments.

Meanwhile, to increase their flexibility and responsiveness, organizations are relying more and more on teams. Besides outperforming individuals, especially when performance requires multiple skills and experiences, teams represent one of the best means to support broad-based changes necessary for high-performing organizations (Katzenbach & Smith, 1993). For organizational learning to occur in team-based organizations, team learning must also occur. Team learning is vital for the success of organizational learning and change once teams are the basic learning unit in most organizations (Katzenbach and Smith, 1993; Senge, 1990).
Although the literature presents a enormous variety of definitions and explanations for organizational and team learning, this thesis focuses on team learning as an ongoing process of reflection and action characterized by learning behaviors such as asking questions and discussing errors (Argyris, 1974; Edmondson, 1996, 1999). Such learning behaviors influence the dynamics of team functioning and performance. But, in order to collectively learn, team members have to suspend their individual assumptions, go beyond personal defensiveness, and present ideas openly (Senge, 1990). For individuals to participate in learning-oriented activities, they need to feel safe and comfortable and to expect that they will not be exposed to situations that threaten their self-esteem (Argyris, 1974).

Even though scholars have stressed the importance of team learning in organizations, there is little empirical research focusing on the conditions under which teams engage in learning behaviors and how such behaviors affect team performance. Moreover, research on this topic has often been descriptive in nature. A few years ago, Edmondson (1996) proposed a descriptive model of team learning in which she argues that team structure and shared beliefs must be analyzed jointly to understand learning behaviors. Her work focuses on psychological safety (the shared belief held by team members that the team is safe for interpersonal risk-taking) as a construct that facilitates learning behavior and influences team performance.

Drawing on Edmondson's model and on theories of organizational learning, mainly those developed by Argyris, Schein and Senge, and making use of the system dynamics tools, my
research work investigates the factors that foster team learning and promote performance in the organizational context. In support of these objectives, I develop a formal simulation model and conduct a series of simulations to understand the dynamics created by learning initiatives and their influences on team performance.

The thesis is organized as follows. In Chapter Two I offer an overview of organizational and team learning theories, including a brief description of Edmondson's model of team learning and an examination of its implications. In Chapter Three I present a brief explanation of feedback loops and capture the descriptive model of team learning into causal loop diagrams. In Chapter Four I develop the formal simulation model of team learning, conduct experiments, and discuss the results. Chapter Five contains discussion and concluding thoughts.

*Research Approach and Focus*

Improving our understanding of existing explanations for organizational phenomena can help to bridge the gap between theory and practice. This thesis focuses on bridging this gap by applying a system dynamics perspective to pre-existing theories of team learning. A system dynamics perspective can blend theory generation and testing. Translating an existing theory into a system dynamics model can generate new understanding, as well as raise new questions about the original theory (Sastry, 1995). Because system dynamics illustrates the interdependencies of the elements acting in the system, there is no single right
answer to the questions raised. Rather, it reveals a set of potential actions to be implemented and thus produce superior results.

To explore the theories, I develop causal loop diagrams as well as a formal simulation model. Through these tools, I capture the feedback dynamics embedded in the system. Feedback processes have been recognized as important tools for the understanding of organizational complexity (Richardson & Pugh, 1981). The simulation model allows dynamic causal theories to be depicted and patterns of behaviors to be analyzed. Then, I develop a formal simulation model and conduct simulation tests to address the question: What are the factors that promote a team's engagement in learning behavior? The results are compared to the theories explored and implications drawn, shedding light in the understanding of team learning initiatives.
Chapter Two

Team and Organizational Learning -- Theory Overview

As discussed in Chapter One, the need for flatter and more flexible organizational structures and for learning and improvement has led organizations to rely more and more on teams, which in turn are required to be more effective, responsive, and learning-oriented. The effectiveness of teams in organizations depends on a set of elements such as organizational culture, team design, reward systems and internal team processes as well as on the ability of teams to learn (Ancona et al., 1996; Hackman, 1990). Team learning is a vital part of organizational learning. But, before going further into the analysis of team learning, an overview of some of the most well known theories on organizational learning is helpful to place team learning in a theoretical context.

The evolution of the interest in organizational learning can be traced back over twenty years ago (Weston, 1994) starting with Donald Michael's book *On Learning to Plan -- and Planning to Learn* in 1973, followed by *Organizational Learning: A Theory of Action Perspective* by Chris Argyris and Donald Schön, 1978. The ever-growing interest of scholars and managers in organizational learning led to a vast literature on the subject (Roth 
& Kleiner, 1996) resulting in distinct definitions of organizational learning. For instance, Argyris and Schön define learning as the process of detecting and correcting errors (1978). Stata sees organizational learning as the process through which organizations modify their behavior by sharing knowledge, insights and mental models, and by building on past knowledge and experience (1989). Levitt and March define organizational learning as the
encoding of inferences from history into routines that guide behavior (1988). This diversity of definitions comes from different theoretical perspectives, some seeking to explain the mechanisms through which learning occurs or fails to occur, while others propose means that promote learning and improve organizational effectiveness. Within these propositions, some researchers in the organizational learning field have presented individual growth and development as the basis for organizational learning to take place. Others have studied how organizations "adapt, change, or process incoming stimuli" as functions of individual cognition or organizational policies and structures (Edmondson, 1996). Human cognition, therefore, plays an important role as leverage or barrier in the organizational learning process.

An organizational level approach is offered by Barbara Levitt and James March, who view organizational learning as "routine-based, history-dependent, and target-oriented" (1988, p.319). They assert that behavior in organizations is based on routines. "Action stems from a logic appropriateness or legitimacy more than from a logic of consequentiality or intuition" (Levitt & March, 1988, p.320). Routines, in turn, are based on interpretation of the past and adapt to experience in response to feedback about outcomes. Within this context, "organizations are seen as learning by encoding inferences from history into routines that guide behavior" (1988, p.320). Organizations have formal routines such as forms, rules, and procedures through which they operate and informal routines such as beliefs, paradigms and codes that support, refine, and contradict the formal routines. Routines and beliefs change over time in response to direct organizational experience, involving two major mechanisms:
trial-and-error experimentation and organizational search, in which organizations are looking for better alternative routines. However, drawn from past learning, routines in organizations can cause change and learning initiatives to be problematic. The lessons of experience are generally drawn from a relatively small number of observations in the complex system of learning organizations. Besides, interpretations of experience come from features of individual inference and judgment, which can lead to biases or misinterpretations. Learning from experience can create barriers to learning at the organizational level such as "superstitious learning" and "competency traps" (Levitt & March, 1988). Superstitious learning occurs when the connections between actions and the desired outcomes are misleading. Similarly, competency traps occur when high level of competence in a particular routine leads an organization to favor the continuity of such a routine even if it is actually inferior. In both cases, perceived need for change may be low, hindering learning.

On the individual level of analysis resides the work of Chris Argyris and his colleagues, who focus on "theory of action":

"A set of rules that individuals use to design and implement their own behavior as well as to understand the behavior of others. Usually, these theories of actions become so taken for granted that people don't even realize they are using them" (Argyris, 1991).

Theory of action is sub-divided into "theories-in-use" and "espoused theories" (Argyris & Schön, 1974). Theories-in-use refer to those theories that people actually use, or in other words, that govern their actions and behaviors. Espoused theories refer to those theories that
people write or talk about and that justify their behaviors (Argyris & Schön, 1974; Argyris, 1982). When dealing with difficult and threatening situations, people do not act congruently with their espoused theories (beliefs, values, and attitudes) but rather congruently with their theories-in-use, a fact of which people are unaware. Within such a context, Argyris and Schön (1974) developed two models of theory-in-use: Model I and Model II.

"The validity of the theories that most people use to design and carry out their actions is tested by their effectiveness in achieving the values people hold" (Argyris, 1977).

People tend to create certain behavioral strategies that are congruent with their "governing values." Under Model I theory-in-use, people are governed by the need to control, to win, to suppress negative feelings, and to be rational. To satisfy these governing values, people use behavioral strategies such as exercising control over others by controlling the meaning of valid information, by owning and controlling tasks, and by unilaterally protecting self and others. These behavioral strategies pose consequences for the actor, for others, and for the organization because they tend to make people defensive and closed since unilateral control does not usually produce valid feedback. Within this context, people do not seek feedback that confronts their actions, and "whatever learning people develop will tend to be within the confines of what is acceptable" (Argyris, 1982, p.88). Such learning is defined as "single loop learning," in which the actors detect mismatches without questioning underlying causes. "Double loop learning," which involves questioning and changing theories-in-use, cannot occur under the circumstances of Model I, because confrontation leads people to engage in "defensive routines," which in turn prevent individuals from learning in many of
the interpersonal interactions that happen in the organizational setting, leading to decreased effectiveness.

Model II is an alternative action strategy designed to elude the counterproductive characteristics of Model I. The governing values of Model II theory-in-use are "valid information," "free and informed choice," and "internal commitment to the choice and constant monitoring of the implementation" (Argyris, 1982). Model II requires genuine inquiry to confront one's views or even change them to produce actions that will lead to the desired outcomes. It emphasizes the building of trust and risk-taking so that positions and ideas can be publicly testable and self-sealing processes reduced. Under Model II, double loop learning is possible once underlying assumptions, values and objectives can be open to confrontation, and once incongruities between theories-in-use and espoused theories can be challenged, leading to error corrections and increased effectiveness.

According to Edgar Schein, "any form of organizational learning is a change process of some sort" once any change involves the creation of something new at the adaptive or generative level (1992, 1994). Adaptive learning is the most basic form of learning and occurs by applying old concepts and skills in new ways (Schein, 1994). Generative learning (Senge, 1990; double-loop learning in Aryris 1974; second-order responses in Levinthal & March, 1981) requires the individual or organization to question long-held assumptions, to develop a new set of concepts, attitudes and behaviors, and to change standards of judgment
(Schein, 1994). For generative learning to take place, Schein argues that three conditions must be met:

(1) enough disconfirming data to cause serious discomfort and disequilibrium;
(2) the connection of the disconfirming data to important goals and ideals causing anxiety and/or guilt; and
(3) enough psychological safety, in the sense of seeing a possibility of solving the problem without loss of identity or integrity, thereby allowing members of the organization to admit the disconfirming data rather than defensively denying it (1992, p.298-299)

Disconfirmation creates two types of anxiety. "Survival anxiety", the feeling that if one does not change, one will fail to meet one's need or goal. This is the anxiety that motivates change. "Learning anxiety", the feeling that if one admits that something is wrong and one needs to change, one will lose effectiveness and self-esteem. This is the anxiety that hinders change. Learning anxiety is a stumbling block to learning because it arouses in individuals fear of incompetence, failure, and punishment for making mistakes. Psychological safety, therefore, plays an important role in providing an environment of trust in which individuals can accept the information, overcome the learning anxiety and become motivated to learn and change (Schein, 1995).

Peter Senge's work on organizational learning also resides on the individual level of learning, in which individuals are constantly developing and refining their mental models.

"Organizations learn only through individuals who learn. Individual learning does not guarantee organizational learning. But without it no organizational learning occurs" (1990, p.139).
Senge describes learning organizations as places:

"where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning how to learn together" (1990, p.3)

To realize these aims, Senge proposes the practice of five disciplines or "component technologies": personal mastery, mental models, shared vision, team learning, and systems thinking.

**Personal Mastery** -- At the individual level, it is the discipline of continually developing one's personal vision and abilities to create the desired results. At the organizational level, personal mastery seeks to create an environment which encourages all its members to develop themselves (1994), therefore fostering learning.

**Mental Models** -- The beliefs, assumptions and concepts that shape one's image of the world. This is the discipline of identifying previously hidden mental models, examining them, and improving them so that people and organizations can gain more capability in governing their actions (Senge, 1990, 1999) and thus learning can take place.

**Shared Vision** -- A group level discipline in which people build a sense of long term commitment by developing a shared picture of the future. When truly motivated, people can expand their ability to create and contribute. Thus, shared vision provides the focus and energy for learning.
Team Learning -- The discipline that deals with the ability of a group of people to suspend their individual assumptions and transform their collective thinking in order to achieve common goals. It means going beyond personal defensiveness and presenting ideas openly. This is achieved through the practice of dialogue and skillful discussion.

Systems Thinking -- The ability and practice of consistently examining the whole system, rather than just trying to fix isolated problems. It is based on system dynamics applications and makes use of conceptual framework and feedback loop analysis to clarify full patterns and to help us understand how to change them most effectively. The complexity of dynamic organizational systems coupled with the effects of feedback delays and non-linearities make it difficult for individuals to understand the impact of their actions in the system. Therefore, systems thinking requires a shift of mind, increasing the awareness that "the human actor is part of the feedback process, not standing apart from it" (Senge 1990, p.78). Systems thinking is the "fifth discipline" since it serves as the means to integrate the other four learning disciplines.

In his most recent book The Dance of Change (1999), Peter Senge, together with his colleagues, argues that, on the one hand, the development of learning capabilities lies at the heart of change. But, on the other hand, learning capabilities are profoundly challenging. Learning capabilities are skills and proficiencies that enable people to consistently enhance their capacity to produce results. In other words, learning capabilities enable people to learn
(Senge et al., 1999). Three capabilities are presented -- aspiration, reflective conversation, and understanding complexity. Aspiration is the capability to orient individuals or groups to create what they desire rather than just react to circumstances. This capability is based on the disciplines Personal Mastery and Shared Vision. Reflective conversation is based on the disciplines Mental Models and Team Learning and nurtures reflection and inquiry, builds shared understanding, and coordinates effective action. Understanding complexity deals with seeing patterns of interdependency and identifying consequences of actions. This capability is based on Systems Thinking.

Developing collective learning capabilities uncovers “rocks that were previously under the [smooth] surface” (p.241). The disclosure of such rocks may cause a sense of fear and anxiety within the team once past mistakes and beliefs come to the surface. People, however, deal differently with the disclosure of “the rocks”. Some feel relatively little threat because their aspirations for growth and effectiveness somewhat outweigh their anxieties. Others feel some discomfort because they do not know where the new openness will take them. But, to some extent, everyone fears to expose themselves, make mistakes, and show ignorance. Senge et al. state that fear and anxiety develop after some progress in developing learning capabilities has been made. Moreover, fear and anxiety “manifest in diverse symptoms” such as “forthright negation,” “objection to ambiguities and alleged side effects,” superficial support,” and “silence”. These symptoms are caused by a gap in openness and candor among members of the team. The gap develops between the growing candor and a limited individual and collective capacity for openness. According to this
theory there are two primary contributors in developing capacity for openness: learning
capabilities and psychological safety. Senge and his colleagues refer to psychological safety
as a condition that enables appropriate risk taking.

"Psychological safety depends on finding a workable balance between aspiration and
trepidation. Aspiration drives learning – for example, the desire to resolve deep
issues, to build new business capabilities to serve customer needs, to shorten time to
market through increasing intelligence rather than increasing effort. But, if people
perceive that their reputation is at stake in order to learn, they may be unwilling to go
forward. ... all learning involve the interplay of risk taking and safety" (Senge et al,
1999, p.246).

**Team Learning**

Within the context of organizational learning, team learning proves to be of crucial
importance. Drawing on literature on organizational learning, self-managing teams, and
mental models, Amy Edmondson has developed a model on team learning which consists of
three basic elements that, working together, improve team performance:

1. Antecedent Conditions -- in which team structures such as context support and
   leadership influence the ability of a team to perform effectively;

2. Team Beliefs -- which encompass shared norms and beliefs that guide or hinder
   learning behavior; and

3. Team Behaviors -- which include activities such as seeking feedback, discussing
   errors, and experimenting that influence performance.
Antecedent Conditions

Building on the work of Richard Hackman (1987), Edmondson suggests that a set of conditions including context support and team leader coaching set the stage for effective team functioning. Context support encompasses the availability and supportiveness of reward and information systems as well as team and task design. An organizational culture that values cooperation, mutual responsibility, and the exchange of information creates a supportive environment for teams as opposed to an individualistic culture that generates barriers and distinctions. Team design refers to the way the team is put together including its composition, the nature of the task and its structure. The mix of skills, backgrounds, and

---

personalities found in team members affects their ability to work together. The nature of the task, which refers to the independence that the team may have, should be considered when the team is formed. Team structure consists of the size of the team, the way the work is distributed and organized, the formal role of each member within the team, and the team goals and norms. Rewards are fundamental in determining how members will interact with one another within the team and with people from outside. Besides supporting the type of teamwork desired in the organization, the reward system needs to provide incentives for collaboration (Hackman, 1990). Team success is amplified to the extent that task completion is designed to require interdependence and the reward structure supports team as well as individual achievement (Ancona et al., 1996).

The other antecedent condition observed in the model is team leader coaching. Team leader behaviors such as coaching and direction setting have been demonstrated to improve team effectiveness. Team leader coaching is likely to influence team psychological safety once a supportive, non-defensive, responsive leader collaborates to create a safe and trustful environment within the team.

"If the leader is supportive, coaching-oriented, and has non-defensive responses to questions and challenges, members are likely to conclude that the team constitutes a safe environment. In contrast, if team leaders act in authoritarian or punitive ways, team members may be reluctant to engage in the interpersonal risk involved in learning behaviors such as discussing errors ... Furthermore, team leaders themselves can engage in learning behaviors, demonstrating the appropriateness of and lack of punishment for such risks" (Edmondson, 1999, p. 356).
Hackman argues that a team leader can promote team effectiveness by "helping team members to learn how to work interdependently" (1990, p.11). However, such effort will be worthless if the team does not have a supportive organizational context or if the team was poorly structured.

In a study about superb self-managed teams conducted at Xerox, Wageman (1997) found that once teams are designed well, leaders have more room to experiment with their own behaviors and learn how to coach effectively, once their mistakes will not harm the teams much. She also finds that coaching has more positive influence on those teams that already had "the majority of success factors in place." By critical success factors she means clear and engaging direction, basic material resources available, rewards for team excellence, performance goals congruent with the organization's objectives, and the presence of norms that promote strategic thinking (Wageman, 1997).

**Team Beliefs**

Team beliefs refer to the construct team psychological safety. Psychological safety, the "shared belief held by members of a team that the team is safe for interpersonal risk-taking" (Edmondson, 1996, 1999), enables team members to speak up and engage in discussions without fearing retaliations and embarrassment. Making mistakes does not lead to rejection but rather to opportunities for discussions and learning. Likewise, if team members don't feel secure to put forward their thoughts and feelings, they do not engage effectively in learning-oriented behaviors, which in turn limit their performance. The willingness to engage in
learning behaviors is inversely related to team perceptions of interpersonal threat (Edmondson, 1996, 1999; Schein, 1996). Most people value the approval of their peers and are likely to engage in behaviors that elicit approval from others (Hackman, Lawler, & Nadler, 1979). But, if the behavior is likely to create personal threat, it is unlikely to be manifested.

Edmondson argues that "team psychological safety facilitates learning behavior in work teams because it alleviates the excessive concern about others' reaction to actions that have the potential for embarrassment or threat, which learning behaviors often have." (1999, p. 355)

**Team Behaviors**

Edmondson's model holds that appropriately composed team structures and shared beliefs of team psychological safety enable team members to engage in learning behaviors, influencing team performance. Edmondson treats team learning as a process through which a team can engage in learning behaviors that will help team members to adapt and improve. Learning behavior comprises activities such as feedback seeking, error discussions, information sharing and experimentation. When team members engage in such activities, the team can learn about customer needs, identify and work on unexpected problems, increase their collective understanding of a given circumstance, or detect changes:

"I conceptualize learning at the group level of analysis as an ongoing process of reflection and action, characterized by asking questions, seeking feedback, experimenting, reflecting on results, and discussing errors or unexpected outcomes
of action. For a team to discover gaps in their plans and make changes accordingly team members must test assumptions and discuss differences of opinion openly rather than privately or outside the group" (Edmondson 1999, p.353).

Learning-oriented behaviors, however, may consume time without assuring positive results, leading to conditions that may reduce efficiency and lower performance. Edmondson asserts that the risk of wasting time can be small relative to the potential gain a team facing change or uncertainty may experience. In this kind of situation, learning behaviors can help the team to better understand their environment and coordinate members' actions in a more effective way (1999).

Ancona and her colleagues refer to team learning as "the team's ability to survive, improve, and adapt to changing circumstances. Learning goals include finding innovative approaches to problems, becoming more efficient over time, acquiring new skills, and changing norms and procedures when external circumstances warrant change" (Ancona et al., m.3 p.21). Senge defines team learning as "the process of aligning and developing the capability of a team to create the results its members truly desire" (1990, p.236). Team learning builds on "shared vision" and "personal mastery," two of the five disciplines of organizational learning proposed by Senge (1990). Team learning has become crucial in organizations since organizations are more dependent on teams to make important decisions or to translate individual decisions into actions (Katzenbach and Smith, 1993; Senge, 1990). Teams can function as disseminators of new insights and skills and their accomplishments can set standards for learning throughout the organization (Senge, 1990). Team learning presents three critical dimensions: (1) think insightfully about complex issues; (2) act in a innovative
and coordinated way based on "operational trust," in which team members respect each others' views and complement their actions; and (3) carry out their actions through other teams. Team learning also involves mastering the practices of dialogue and discussion. The purpose of dialogue is to provide individuals with new insights that they could not achieve individually. With dialogue, a team can explore complex issues from different points of view since individuals can communicate their assumptions freely. In order to do so, individuals need to feel secure about expressing their ideas without being retaliated against (psychological safety). Discussion, conversely, encompasses the presentation and defense of different views focusing on a "search for the best view to support decisions that must be made" (1990, 243-245). Feedback is also a critical tool for team learning. "Feedback is the non-judgmental observation that others offer. It is a picture of how effectively one's behavior or action is helping to move the person or team toward the desired outcome or goal" (Ancona et al., 1996, module 3, p.34). Learning is difficult in situations where feedback is slow and incomplete (March, Sproull, and Tamuz, 1991). To be helpful, the feedback must contain valid information and be communicated in a way that does not make the receiver defensive and therefore unlikely to hear the information (Argyris, 1982). Team learning also involves learning how to deal with "defensive routines" (Argyris, 1974) or "learning anxiety" (Schein, 1992), forces that thwart productive dialogue and discussion in teams, therefore preventing learning from taking place.
"System dynamics is a method to enhance learning in complex systems" (Sterman, forthcoming). Effective learning in complex environments requires methods, tools and principles to develop systems thinking so that the interrelationship of forces that affect the system can be identified and assessed. Senge argues that conventional forecasting, planning, and analysis methods are not equipped to deal with dynamic complexity, or situations in which cause and effect are subtle and the effects of interventions are not obvious (1990). System dynamics, on the other hand, helps us to learn about dynamic complexity, to understand how the feedback structure of complex systems produces patterns of behavior, and to discuss interrelationships more comfortably.

The dynamics of a system arise from the interaction of two types of feedback loops: positive or reinforcing loops and negative or balancing loops. Positive or reinforcing loops are self-fueling and "tend to reinforce or amplify whatever is happening in the system" (Sterman, forthcoming). They generate their own growth or decline leading to exponential growth or exponential collapse, in which the growth or collapse continues at an increasing rate.

Negative or balancing loops are self-correcting and seek to restore balance. Balance processes tend to be bound to a target and whenever the current state of the system does not match this target, a gap is generated, creating a pressure that the system cannot ignore (Senge, 1990; Senge et al, 1994; Sterman, forthcoming).
Causal loop modeling is an important tool for representing the feedback structure of systems.

"Causal loop diagrams are excellent for quickly capturing [one's] hypotheses about the causes of dynamics; eliciting and capturing the mental models of individuals or teams; and for communicating the important feedbacks [one] believed to be responsible for a problem" (Sterman, forthcoming).

A causal loop diagram consists of variables linked by arrows indicating the causal influence of one variable on another. Each arrow or causal link is assigned a polarity, either positive (+) or negative (-) to denote in which way a change in an independent variable influences a dependent variable.
This diagram illustrates a positive or reinforcing feedback loop. Imagine the sales and production process of a product. More sales of a product will require more production of such a product, which means more product availability that will lead to potential sales. On the other hand, less sales lead to less production, and the fewer products are available, the lower the potential sales will be.
Figure 3: Negative Feedback Loop Diagram

This diagram illustrates a negative or balancing feedback loop. The level of production of a product affects the level of inventory of such a product. As the level of inventory changes, the gap between the current and the desired level of inventory also changes. Production will depend on the size of the gap. If the gap is big, production will be high to bring inventory to the desired levels. If the gap is small, production will be low, just enough to close the gap.
In mathematical terms, the feedback loop diagrams are defined as:

\[ x \rightarrow y \Rightarrow \frac{\partial y}{\partial x} > 0; x \rightarrow y \Rightarrow \frac{\partial y}{\partial x} < 0 \]

A positive signed arrow from \( x \) to \( y \) indicates that the partial derivative of \( y \) (the effect) with respect to \( x \) (the cause) is positive, and a negative signed arrow indicates a negative partial derivative. A positive link means "all else equal, if \( x \) increases (decreases), then \( y \) increases (decreases) above (below) what it would have been." A negative link means "all else equal, if \( x \) increases (decreases), then \( y \) decreases (increases) below (above) what would have been" (Sterman, forthcoming).

Link polarities describe the structure of the system rather than the behavior of the variables (Sterman, forthcoming). An increase in a cause variable with positive link polarity does not necessarily mean that the effect variable will also increase. This happens because a variable often has more than one input and because causal loop diagrams do not distinguish between stocks and flows. Stocks represent "the accumulation of resources in a system" while flows represent "the rates of change that alter those resources" (Sterman, forthcoming). As Sastry notes:

"if \( y \) represents a stock that accumulates over time, a negative influence on a stock would reduce the inflow, making the stock's value lower than it would otherwise have been, but not necessarily lower than it was in the past ...Because such problems can make it difficult to interpret causal loop diagrams (Richardson, 1986), the special role played by accumulating stocks must be recognized in correctly inferring behavior from feedback-loop structure" (1995, p. 50).
The polarity of the loop can be determined by tracing the effects of a small change in one of the variables along the causal links of the feedback loop. If the net effect reinforces the initial change, the loop is positive or reinforcing; if the net effect opposes the initial change, the loop is negative or balancing. A fast way to determine the polarity of the loop is to count the number of negative links along the causal loop diagram. The loop is positive if it contains an even number of negative links, and negative if it contains an odd number of negative links (Richardson, 1991; Sterman, forthcoming). Positive or reinforcing loops are represented by the loop identifier "R," while negative or balancing loops are represented by the loop identifier "B."

Causal Loop Diagrams to Represent Learning Behaviors

As mentioned earlier, causal loop diagrams are designed to convey the central feedback structure of dynamic hypotheses. Below, I present the causal loop diagrams seeking to capture the dynamics of the team learning behaviors, previously discussed in this thesis. According to Edmondson's team learning model, psychological safety enables learning behaviors, leading to team learning, which in turn fosters effective team performance. I argue that the cycle completes with team performance influencing psychological safety. The higher the performance of the team, the more the team will feel confident and comfortable to engage in learning-oriented activities, leading to a virtuous cycle. I included the variable confidence in the causal loop to represent the team self-confidence, a construct that according to Argyris is central to effective action:
"Self-confidence means that people believe they are effective, self-governing systems in the world in which they are embedded. People who feel self-confident are those who have had success in designing and implementing their actions and in detecting and correcting any errors that they may have produced. Such people enter a situation with a greater degree of certainty that they can behave competently" (1982, p.97).

Once the members of the team feel self-confident, it is likely that their sense of safety will improve, closing the loop.

"This sense of certainty makes them less vulnerable and hence more likely to identify and correct errors. This outcome reinforces their sense of competence and their sense that the world is basically just" (Argyris, 1982 p.97).

The variable confidence thus mediates between team performance and psychological safety. The higher the team self-confidence, the higher the feeling of safety, and therefore, the more the team as a whole will engage in learning-oriented activities. Conversely, a lack of confidence will lead to lower psychological safety, contributing to the team's reluctance to engage in learning behaviors. Experiencing a low safety environment, team members will be reluctant to seek feedback or ask for help for fear of criticism, retaliation or management sanction. In an environment with little trust, learning anxiety (Schein, 1992) will take over and members will not engage in learning-oriented activities for fear of losing effectiveness and self-esteem. The team is likely therefore to experience lower performance, which will contribute to reducing psychological safety even further. This will therefore result in a vicious cycle. The dynamics described above are represented by the reinforcing loop R learning.
An increase in team performance may raise the sense that the need for active coaching is no longer necessary. If the team is performing better, the leader may become complacent and not be so proactive as she used to or may stop helping team members effectively. Thus, the team leader starts coaching or helping members less. Such a decrease in coaching may be perceived negatively by team members, leading to a decrease in the level of team psychological safety (Edmondson, personal communication). Conversely, lower team performance will signal a greater need for leader coaching. Once the leader contributes to creating a safe and trusting environment, the level of psychological safety will increase and team members will engage in learning-oriented activities. These dynamics are represented below by the balancing loop B coaching. Context support, as mentioned earlier (Ancona et al., 1995; Edmondson, 1996, 1999; Hackman, 1990), positively influences the level of psychological safety within a team since context support provides the team with the basic conditions that the team needs for effective functioning. As team members feel that they are
part of a supportive environment, their sense of safety will increase. Context support is treated as an exogenous variable to the model, since the team most of the time has no control over such organizational contexts as reward systems, team and task design, and access to information.

![Diagram](image)

**Figure 5: Integrating the Balancing Loop Team Coaching into the Model**

The dynamics of the model are completed by the balancing loop B task execution. Learning behaviors have two different effects on team performance. First, learning behaviors positively affect team performance through team learning, as shown above and captured by the reinforcing loop R learning. The second effect refers to the fact that learning behaviors will consume time no matter the level of productivity the team is at. Thus, learning
behaviors will have a negative impact on the execution of tasks. Context support positively affects routine task execution since resources, access to information and adequate task design helps the team to work more effectively (Hackman, 1990).

Figure 6: Integrating the Balancing Loop Routine Task Execution into the Model
The combination of the reinforcing loop R learning and the two balancing loops B coaching and B task execution provides equilibrium to the model. Learning behaviors and team performance cannot go up or down forever and the balancing loops in the system prevent them from doing so. This condition can be characterized as "limits to growth" (Senge, 1990; Senge et al., 1999). Limits to growth occur when a reinforcing process is set in motion to produce a desired result or a period of accelerating growth, and a balancing process starts operating and eventually slows down the success or even generates an accelerated collapse. The slowing arises because a balancing loop starts operating when a "limit" is approached. The accelerating collapse, when it occurs, is triggered by a reinforcing loop. Therefore, in the learning/performance case, as the team learns, its performance will improve, but there are certain aspects such as a reduction in team leader coaching or constraints in organizational context that may limit the engagement of the team in learning-oriented activities.

Senge et al. (1999) suggests four basic strategies to deal with limits to growth situations.

1. "Don't push so hard for growth" -- Limits to growth situations tend to develop at two stages, "an initial phase of accelerated growth, and then a discomfiting slowdown" (p.61). Balancing forces start operating and confronting one's actions, causing a slowdown in the system. Therefore, it is important to reduce rather than speed up the pace. This will enable those involved to evaluate their actions, think about their consequences, correct the course whenever necessary.
2. "Think about the future today"-- This strategy deals with looking ahead to identify forces that may cause slowdowns in the system, the sources and characteristics of resistance, and its possible impacts on the group.

3. "Conduct experiments" -- Experimentation can help individuals as well as groups to develop a learning orientation in which solutions are treated as hypotheses, rather than as answers. Moreover, a series of experiments may be conducted so that results can be analyzed and conclusions drawn. It is important to keep in mind that the experiments may not work.

4. "Reset the goals by examining your mental models" - Situations or "limits" that hinder organizational learning initiatives are strongly related to the mental models embedded in the culture of the organization. Learning and change initiatives may therefore cause resistance because they will probably confront people's long-held beliefs and assumptions. So mental models must be deeply examined and priorities established.

With the big picture of team learning and its feedback dynamics in mind and with the awareness of limits to growth that may arise in the way of learning initiatives, I will in Chapter Four address the next proposition of this thesis -- building the formal simulation model, simulating it, and analyzing the results.
Chapter Four

Modeling Team Learning

Challenges in Building the Dynamic Model

The theory of team learning that provides the basis for the system dynamics model inevitably simplifies the real world situations that it intends to explain. A simulation model of any theory has to specify within the theory and make further simplification. In addition, as Edmondson points out, "little research has been done to understand the factors that influence learning behaviors in ongoing teams in real organizations" (1999, p.350). Therefore poor understanding of real-world situations leads to less powerful models since there may be a lack of strong background. Moreover, I am testing my results against a theoretical model of team learning rather than against empirical data. The theory of team learning deals with individual mental models, beliefs, and anxieties, leading to a quite abstract model with constants and variables difficult to measure or quantify, as is the case with feedback practice and team self-confidence.

Model formulation

In this section, I present a step-by-step discussion about the dynamic representation of the team learning model. To explain the principles guiding the translation of the theory into the formal simulation model, I start with a brief description of the criteria used for its formulation.
• Criteria for formulating the model

- The simulation model should depict Edmondson's team learning descriptive model and provide endogenous explanations whenever the theory did so. Further organizational learning theory should be studied to provide an understanding of endogenous and exogenous determinants of learning behavior.

- The simulation model should attempt to accurately represent real-world situations, variables should have real meanings that could be measured, and model results should be compared to actual team behaviors. Units of measurement should include proxies whenever possible (given that this is a quite abstract model). Since the model deals with mental models and perceptions, this requirement increases the validity of the model constructs.

• Model specification

I sought to build the simplest possible model that captures the dynamics of learning behaviors and their impacts on team performance. Although learning-oriented behaviors in Edmondson's model encompass different activities such as feedback seeking, error discussions, information sharing and experimentation, I included in the model two variables to represent team learning-oriented activities: discussion and dialogue practice and feedback practice. Discussion and dialogue practice represents the practices of discussing errors and mistakes and sharing information among team members. Feedback practice represents seeking information about a team's progress toward some goal, generally outside the team.
Despite the apparent oversimplification of the model, such variables can capture the causal roles of relevant theory and constructs. For example, according to organizational learning literature, these two behaviors are fundamental for team learning to take place (Ancona et al., 1996; Schein, 1999; Senge, 1990). As I go through the model formulation, I will, whenever necessary, relate the variables and constants included in the simulation model to those presented in the causal loop diagrams in Chapter Three.

In the model, *Psychological Safety* is a stock representing the accumulation over time of the shared belief that the team is safe for interpersonal risk-taking. Psychological safety varies from zero to one.

\[
\text{Psychological Safety} = \\
\int \text{building psychological safety } dt + \text{Initial fraction of Psychological Safety}
\]

Flows or rates of change alter the level of a stock. The rate of change in the level of psychological safety is represented by building psychological safety and given by the difference between indicated psychological safety and the actual level of psychological safety divided by the time it takes to gain or lose safety:

\[
\text{building psychological safety} = \frac{\text{Indicated Psychological Safety} - \text{Psychological Safety}}{\text{Time to gain or lose safety}}
\]
Indicated psychological safety represents the level of psychological safety that the team ideally should have to operate at optimal performance. It has three basic components: normal level of psychological safety, effect of team self-confidence and team leader coaching.

\[
\text{Indicated Psychological Safety} = \frac{\text{Normal Level Psych. Safety} \times (\text{Effect of Team Self Confidence} \times W1 + \text{Team Leader Coaching} \times W2)}{(1 - W1)}
\]

First, normal level of psychological safety represents the level of safety that an adequate organizational context should provide for teams to engage in learning-oriented activities. Adequate organizational context represents access to information that might be relevant for the team to complete its tasks; reward systems that foster collaboration and collective rather than individual work; and team design that mixes skills and experiences that are important to the completion of the tasks. Organizational context is defined in the literature and corroborated by field research (Ancona et al., 1996; Edmondson, 1996, 1999; Hackman, 1983) to be of fundamental importance for teams to flourish and function effectively in the organizational environment. Normal level of psychological safety refers to context support in the causal loop diagrams.

The second component is the effect of team self-confidence. Self-confidence provides team members with the sense that they behave competently, thus influencing the team's level of psychological safety. In the model self-confidence is a function of perceived performance.
Effect of Team Self Confidence = Confidence function (Perceived Performance)

As common sense suggests, the confidence function should slope upward; the higher (lower) the perceived performance, the higher (lower) team's self-confidence will be. In the model a table function\(^2\) denominated confidence function represents how the perception of team members affects their level of self-confidence. The curve is s-shaped representing the assumption that near the right-hand and left-hand limits, small changes in perceived performance are likely to slightly influence self-confidence, not so much to affect the level of psychological safety.

![Effect of Performance on Team Self-Confidence](image)

*Figure 7*

---

Table functions are represented by graphs showing the influences of one variable (input or x) on another (output or y).
The third component is team leader coaching. Team leader plays an important role in promoting team effectiveness and helping build commitment and trust. Here team leader coaching is defined by the effect of team leader coaching multiplied by leader skills. Team leader skills affect the ability of the leader in effectively coaching the team. Its measure goes from zero to one.

\[ \text{Team Leader Coaching} = \text{Effect of Team Leader Coaching} \times \text{Leader skills} \]

where,

\[ \text{Effect of Team Leader Coaching} = \text{Coaching function (Perceived Performance)} \]

Like self-confidence, team leader coaching is also a function of perceived performance. The need for team leader coaching is inversely associated with perceived performance. A high level of perceived performance will signal a lower need for leader coaching. The coaching
function slopes downward, representing the assumption that the lower the performance, the more the leader coaches. As perceived performance increases, leader coaching decreases at an increasing rate. The inflection point is at point 0.5, and then the curve decreases at a decreasing rate. The right hand limit does not approach zero because the leader will still coach even if at a lower extent. The S-shape of the curve represents the assumption that near the left- and right-hand limits, small changes on the perceived performance have little effect on leader coaching.

Different weights were attributed to the variables team leader coaching and effect of team self confidence to give more room for analysis of the impacts of these two variables on the level of psychological safety as well as on the dynamics of the system. (Further details about the formulations are provided in the appendix.)

The level of psychological safety will affect the engagement of team members in learning-oriented activities. As the level of psychological safety increases, the team is more likely to engage in learning-oriented activities. Thus, both learning behaviors, discussion and dialogue practice and feedback practice represented in the model, are affected by the level of psychological safety experienced by the team. Discussion and dialogue practice is measured by conversations. Conversations represent the practice of dialogue and discussion of relevant issues and points of view focusing on the search of best processes or methods for the completion of a task. Feedback practice refers to non-judgmental observations offered by others outside the team to help the team move toward the desired outcome. This construct is
measured in dimensionless units. Two table functions were incorporated in this sector of the model to capture the mental model of team members in relation to the learning behavior practices.

![Effect of Psychological Safety on Learning Behaviors (Discussion and Dialogue Practice)](image)

Figure 9

![Effect of Psychological Safety on Learning Behaviors (Feedback Practice)](image)

Figure 10
A table denominated D and D (Figure 9) function captures the behavior of the team in relation to the practice of discussion and dialogue. Similarly, a table function denominated feedback function (Figure 10) seeks to capture the perception of the team regarding the practice of feedback. To participate in learning-oriented activities, team members expect that they will not be exposed to uncomfortable and face-threatening situations. This suggests that the effect of psychological safety on learning behaviors increases as team members feel safer. Common sense suggests that the "learning" functions should slope upward, in which the more psychological safety, the greater the engagement in learning-oriented activities. The left-hand limit approaches zero since there will be no learning-oriented activities in the absence of psychological safety. As the level of psychological safety increases, learning behaviors increase at an increasing rate. The inflection point is at point 0.5, and then the curve increases at a decreasing rate. Once more, the S-shape of the curves represents the assumption that near the left- and right-hand limits, small changes on the level of psychological safety have little effect on learning behaviors. If the level of psychological safety is too low, there will be no sustainable engagement from the part of team members. Similarly, when the team feels safe, small changes in the level of psychological safety have little impact on learning behaviors.

The practices of discussion and dialogue and feedback seeking positively affect team learning. The variable team productivity captures the effects of such dynamics. Team learning will lead to an improvement on the team effectiveness. Therefore, the improvement generated by learning behaviors, or team learning, will affect the current rate of productivity
of the team. The variable Indicated Team Productivity mediates between the effects of the learning behaviors and team productivity.

\[
\text{Indicated team productivity} = \\
\text{Minimum Productivity} \times (1 + (\text{Effect of D and D Practice} \times \text{Feedback Practice}))
\]

Indicated team productivity represents the level of productivity the team will reach by engaging in learning behaviors. A multiplicative relationship is consistent to represent that no engagement at all in either learning activities leads the team to operate at its minimum level of productivity. On the other hand, a complete engagement in both learning activities causes team productivity to double. Although a team may experience some level of learning by engaging in one or the other activity, both activities interact to produce learning results. A team may collect feedback but not discuss the information and comments gathered, leading therefore to a decrease in the effectiveness of the feedback. Similarly, if the team has discussions, but nothing concrete to discuss, the effectiveness of the dialogue and discussion practice can be fruitless.

The time consumed in dialogue and discussion practice negatively affects routine task execution; that is, if the team engages in too many discussions and spend too much time doing so, the time to complete tasks will be compromised, leading to less work done. This dynamic is captured by the variable Indicated task completion rate:
**Indicated Task Completion Rate** = **Team Productivity** * \((1 - \text{fraction of time lost in conversation})\)

Team productivity is a stock representing the level of productivity the team can achieve. Like the other stocks, at time \(t\), team productivity is the integral of all previous changes in team productivity, plus its initial value.

\[
\text{Team Productivity} = \int_0^t \text{learning how to be more productive} \ dt + \text{Initial Productivity}
\]

The rate of change of team productivity is given by

\[
\text{learning how to be more productive} = \frac{(\text{Indicated team productivity} - \text{Team Productivity})}{\text{Time to Learn}}
\]

The parameters for team productivity were based on tasks developed by a New Product Development Team assuming that such a team works on one project per year (Edmondson, personal communication). Two stocks, Tasks and Tasks Completed, were included in the simulation model in order to provide a quantifiable aspect to performance evaluation in which the team is evaluated by the number of tasks it completes over a certain period of time. The number of tasks completed depends on either the indicated task completion rate determined by productivity or on the completion rate determined by the number of tasks the team has to complete divided by the minimum time to complete these tasks.
completing tasks =

\[
\text{Min(Indicated Task Completion Rate, Tasks/Minimum Time to complete task)}
\]

where,

\[\text{Indicated Task Completion Rate} = \text{Team Productivity} \times \text{fraction of time lost in conversation}\]

Since it is difficult to measure performance instantly, the model captures manager’s reactions to perceived performance rather than actual performance. Perceived Performance is given by comparing the level of Desired Tasks Completion Rate and the level of Perceived Tasks Being Completed.

\[
\text{Perceived Performance} = \frac{\text{Perceived Tasks Being Completed}}{\text{Desired Tasks Completion Rate}}
\]

Desired tasks completion rate is a constant that depicts the level of performance (or productivity) the organization wants to achieve. It is usually defined by managers, the team leader, or even the team itself, depending on the structure of the team and/or the organization. Perceived tasks being completed is a smooth of completing tasks and time to perceive performance. A smooth represents a delay in the system.

\[
\text{Perceived tasks being completed} =
\text{SMOOTH (completing tasks, time to perceive performance)}
\]
Performance refers to how well team members produce output, measured in terms of quality, quantity, timeliness, efficiency, and innovation. (Ancona et al., 1996). Measuring team performance is complex because it depends not only on the team output but also on internal standards specified by the team's social system (Hackman, 1990). Hackman suggests three dimensions to measure team performance or effectiveness, one of which encompasses the degree to which the team's productive output (products or service) meets the standards of quality, quantity and timeliness of people who receive or use the output. The other two dimensions refer to internal team structures and social systems and are not captured in the model.

The model does not capture changes of team members. It is assumed that either the same individuals work together along the period of analysis or the members who leave the team are replaced by others with the same level of skills, not impacting the productivity of the team. But the model does capture the impact of leaders. That is achieved through the variable leader skills.

There are six loops in the model, three reinforcing loops that improve the level of psychological safety and team productivity, and three balancing loops that prevent the team from improving.
Reinforcing Loops

- R1 represents the dynamics of discussion and dialogue practice and their effects on team learning behaviors and performance.
- R2 represents the dynamics of feedback practice and its effects on team learning behaviors and performance.
- R3 represents the effects of task execution on team leader coaching.

Balancing Loops

- B1 represents the effects of discussion and dialogue practice on team leader coaching.
  B2 represents the effects of feedback practice on team leader coaching
- B3 represents the effects of discussion and dialogue on task execution.
Figure 11: The Formal Simulation Model
Simulating the Dynamic Model

A systematic approach was used to explore the simulation model. First, initial equilibrium conditions tests were specified and equilibrium tests conducted. Second, a base case was introduced and examined. Finally, different sets of simulations were conducted to explore the conditions under which a particular structure plays a key role in determining the dynamics of the system.

A stock is in equilibrium when it is unchanging (Sterman, forthcoming). For a stock to be in equilibrium the net rate of change must be zero, implying that the rate of inflow must equal the rate of outflow. In the case of the stock psychological safety, the rate of inflow and outflow is already represented by the net rate building psychological safety. Therefore, for the stock of psychological safety to be in equilibrium, building psychological safety must equal zero. The same case applies to the stock Team productivity, in which the net rate learning how to be more productive represents the inflow minus the outflow.

Under initial conditions the level of psychological safety is set equal to indicated psychological safety, which represents the effects of team self-confidence, leader coaching and normal level of psychological safety on psychological safety. Team productivity equals indicated team productivity, which captures the effects of learning on team performance. The rate of introducing tasks is equal to the rate that the team completes its tasks, therefore there will be no accumulation of tasks. Finally, all four table functions go from zero to one, showing linear response of team members to the effects of psychological safety on learning.
behaviors and of self-confidence and leader coaching on psychological safety. The parameter values of the simulations are shown in the appendix. The initial conditions for equilibrium are shown below.

Psychological Safety initial condition:

\[ \text{Building psychological safety} = 0 \]

\[ \text{Indicated Psychological Safety} - \text{Psychological Safety} = 0 \]

\[ \text{Time to get or lose safety} \]

Therefore,

\[ \text{Psychological Safety} = \text{Indicated Psychological Safety} \]

Team Productivity initial condition:

\[ \text{Learning how to be more productive} = 0 \]

\[ \text{Indicated Team Productivity} - \text{Team Productivity} = 0 \]

\[ \text{Time to Learn} \]

Therefore,

\[ \text{Team Productivity} = \text{Indicated team Productivity} \]

Tasks and Tasks Completed initial condition:

\[ \text{Introducing tasks} = \text{completing tasks} \]
Two different equilibrium tests were simulated. The first equilibrium test captures an environment that does not support or motivate team members to engage in learning-oriented behaviors (this was achieved by setting normal level of psychological safety equal to zero, besides applying the initial conditions described above). In this case, the team will not feel safe to embrace learning activities for fear of retaliation or embarrassment. With the lack of experimenting and learning, the team will not improve its productivity, which will reflect in lower performance evaluations, which in turn will harm the morale of team members, leading to a negative impact in their self-confidence.

The second equilibrium test captures a supportive environment in which team members do engage in learning-oriented activities (in this case normal level of psychological safety is set at one - its maximum level). Team members therefore will experience higher levels of psychological safety, learning and performance. The steady state can be observed at high levels of psychological safety and performance.
Figure 12: Equilibrium Test I -- low level of normal psychological safety

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<td>dimensionless</td>
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<td>tasks/month</td>
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<td>dimensionless</td>
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<tr>
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<td>tasks/month</td>
</tr>
<tr>
<td>0</td>
<td>dimensionless/month</td>
</tr>
</tbody>
</table>

Psychological Safety: Equilibrium
Team Productivity: Equilibrium
Feedback Practice: Equilibrium

Figure 13: Equilibrium Test II -- high level of normal psychological safety

<table>
<thead>
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</thead>
<tbody>
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<td>0</td>
<td>tasks/month</td>
</tr>
<tr>
<td>0</td>
<td>dimensionless/month</td>
</tr>
</tbody>
</table>

Psychological Safety: equilibrium II
Team Productivity: equilibrium II
Feedback Practice: equilibrium II
As the equilibrium tests are passed, the next step includes the simulation of the model to understand the dynamic implications of the team learning theory outlined earlier in this thesis. The model was simulated to highlight the role of key constructs such as the level of psychological safety, team leader coaching, and team performance.

The Base Case

The base case simulates a scenario in which a team starts out with no psychological safety and at the minimum level of productivity. However, the team has a skillful and supportive leader and the normal level of psychological safety is set at its highest level to depict a supportive organizational context. This scenario illustrates a team that has no previous experience in working together, but the environment and the skills are set to provide support for team members to perform efficiently. A higher weight is attributed to team self-confidence than to team leader coaching in order to shed light on the role of these two constructs. (Further analysis is conducted later in the thesis). Further details on the simulation parameters are available in the appendix. The simulation results for the base case are shown below.

Initially, psychological safety builds up rapidly and continues to build at a decreasing rate, exhibiting a pattern of goal seeking behavior until it reaches a fairly steady level by month 30. Team productivity follows the predicted path of an "S-shaped growth" -- growth is
exponential at first and gradually slows until the state of the system reaches the equilibrium level. At the beginning of the learning initiative, the balancing loops B1 and B2 drive the behavior of the system. Once positive results start to appear, the reinforcing loops R1 and R2 work in a virtuous direction and engagement in learning-oriented activities increases. The gap between the manager's goal for performance and the actual level of team performance functions as a motivation for the team to engage in learning-oriented activities. Once actual performance reaches the manager's goal, additional engagement in learning behaviors becomes unlikely. Since there is a delay for learning-oriented activities to show results and for managers to perceive performance, the team will continue to increase their engagement in such activities. Yet long time delays and large gaps can work in a counterproductive way in the system. Long time delays can create the perception that the learning initiatives are fruitless because results will take time to appear. A large gap in performance can lead to negative evaluations, undermining the learning initiative.

Figure 14: The Base Case -- Team Psychological Safety
Figure 15: The Base Case -- Team Productivity

Figure 16: The Base Case -- Performance Goals
The base case illustrates a possible behavior mode generated by the manager's goal for team performance, which may function as a motivation for team members to engage in learning behaviors. Team learning will help the team to improve its productivity and reach the desired performance target. Given the base case as a benchmark, I am now ready to explore other potential behavior modes and focus on how well the simulations match the predictions from the theory and from the original descriptive model and on which factors may foster team engagement in learning behaviors.

Simulation Results

*Manager's goal for team performance*

In a subsequent set of simulations, the manager's goals for tasks completion rate (or team performance) is varied 50% below and 50% above the desired level of tasks completed per month. By setting a very aggressive performance goal, managers will be indirectly preventing team members from engaging in learning-oriented activities. The large gap between the desired and the actual levels of team performance keeps the team learning at lower levels. This happens because the balancing loops B1 and B2 dominates and the reinforcing loops R1 and R2 are not strong enough to stimulate growth. The team's level of self-confidence will be harmed by non-favorable evaluation results, hindering the build up of psychological safety. Moreover, they are likely to operate as limits to growth and should therefore be reexamined.
In contrast, the simulations show that less aggressive performance goals are preferable because they will set lower manager's expectations and more favorable performance evaluations. Positive evaluations will generate enough psychological safety to trigger the reinforcing learning loops R1 and R2 to work in a virtuous cycle. Once the team engages in learning behaviors earlier in the process, results will appear more quickly. Therefore, the simulations highlight the fact that goal performance functions as a motivation for team learning.

Figure 17: Impact of Performance Goals on Psychological Safety

Psychological Safety : base case
Psychological Safety : 50% above desired tasks' goal
Psychological Safety : 50% below desired tasks' goal

dimensionless

Time (month)
The Role of the Leader

The role of the leader has been argued to be of high importance for teams. The leader can promote team effectiveness by helping team members learn to work interdependently, building commitment to the group and its task, and coordinating the implementation of performance plans (Hackman, 1990). The same way that a supportive and responsive leader can help build psychological safety within the team, a defensive, non-motivational leader can hinder it. To simulate such predictions the constant leader skills was varied between zero and one. The simulation results corroborate the theory that the leader plays a relevant role within the team. Subsequent simulations buttress this case.
Figure 19: Impact of Leader Skills on Psychological Safety

Psychological Safety: great leader (base case)  
Psychological Safety: not-so-good leader  

Figure 20: Impact of Leader Skills on Indicated Performance

Indicated Task Completion Rate: great leader (base case)  
Indicated Task Completion Rate: not-so-good leader  

Wageman (1997) argues that leaders do have an important role in the life of teams, but such role varies at different phases along the team's life. She describes three distinct and critical roles: designer, midwife, and coach. The first two roles take place when the team is first launched and after its launching, respectively. As a designer, the leader will set directions for the team, design task and reward system when it is the case, and make sure the team has access to basic material resources. As a midwife, the leader works together with the team to set the team's goals and the norms that will govern the team, its interaction and the use of resources. Then coach role takes over and continues throughout the life of the team. Once the team is well-designed, the leader will be able to experiment new managerial actions without harming the team performance because the team is strong enough to "bounce back from inappropriate leader actions" (Wageman, 1997, p.39).

With this in mind I conducted two distinct sets of simulations. In the first set, the team experiences the loss of a great leader; in the second set, the leader steps back temporarily for training or decides to experiment with, as Wageman points out, new managerial actions.

The first simulation set takes into account two different scenarios: (1) the loss of the leader at time equals ten, and (2) the loss of the leader at time equals thirty. The loss of the leader was simulated by introducing a step decrease in the constant leader skills in month 10 and month 30, respectively. The simulation results for the loss of leader case are shown in figures 21 and 22. Psychological safety, as well as team productivity, decreases in both cases. The drop is more accentuated in month 10, when the team is still building up its level
of psychological safety, and at about month 14, the system resumes its growth. Without coaching or help, the team will experience a drop in productivity. Such a drop will lead to an increase in the gap between the manager's goal for performance and actual performance. Once the gap is efficiently large, team members will have motivation to engage in learning-oriented activities in order to improve their performance and close the gap.

A surprising aspect of the loss of the leader in month 30 is that the team does not get better at all, reaching a steady state at a lower level of psychological safety and productivity six months after the event. It was expected that the team would recover even more at this time than at an earlier stage, once it had already reached a reasonable level of psychological safety and the team productivity was above the target. But these same reasons prevented the team from fully recovering to its previous level. As in the former case, the team will suffer from losing its leader and without help or coaching, team members will experience a drop in their productivity. But, in this case team members no longer have the motivation to further engage in learning-oriented activities since they have reached the target level for performance. Under this scenario, the balancing loops B1 and B2 dominate, and once the gap of performance starts to close when perceived performance reaches manager's target, the system follows a steady state.
Figure 21: Impact of Leader on Psychological Safety

![Graph showing the impact of leader on psychological safety over time.](image)

- Psychological Safety: great leader (base case)
- Psychological Safety: loss of great leader at t=10
- Psychological Safety: loss of great leader at t=30

Figure 22: Impact of Leader on Indicated Performance

![Graph showing the impact of leader on indicated performance over time.](image)

- Indicated Task Completion Rate: great leader (base case)
- Indicated Task Completion Rate: loss of great leader at t=10
- Indicated Task Completion Rate: loss of great leader at t=30
The second set of simulations examines the "temporary" withdrawal of the leader. This scenario was simulated by introducing a step decrease in month 10 and a step increase in month 20 in the constant leader skills. One can observe from figures 24 and 25, that the level of psychological safety and team performance (indicated task completion rate) suffer from the temporary withdrawal of the leader in month 10. The team starts its way through recovery approximately four months later, which speeds up with the return of the leader in month 20. This simulation in part corroborates Wageman's theory that a well-designed team will be able to "bounce back from inappropriate leader actions." However, further analysis in the field should be carried out in order to examine how far a team can go and still recover completely without harming performance.
Figure 24: Impact of Leader Temporary Withdrawal on Psychological Safety

![Graph showing the impact of leader temporary withdrawal on psychological safety over time.]

- Psychological Safety: base case
- Psychological Safety: leader experimenting
- Psychological Safety: loss of great leader at t=10

Figure 25: Impact of Leader Temporary Withdrawal on Team Performance

![Graph showing the impact of leader temporary withdrawal on team performance over time.]

- Indicated Task Completion Rate: base case
- Indicated Task Completion Rate: leader experimenting
- Indicated Task Completion Rate: loss of great leader at t=10

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Leader Coaching and Self-confidence

A set of simulations in which the weights of team leader coaching (W1) and of self-confidence (W2) were varied shows that a higher weight in the variable team leader coaching will cause the system to follow an overshoot and collapse pattern. At the beginning of the simulation, perceived performance is low, leading to a perceived need for more coaching and help. Such coaching will increase the level of trust and safety within the team so that members will engage more quickly and easily in learning-oriented activities. The effects of learning behaviors will cumulatively build up team productivity. But, as soon as perceived performance starts to increase, the perceived need for leader coaching starts to decrease. Such decrease in leader coaching may be perceived negatively by team members, leading to a decrease in their level of psychological safety. Here, the balancing loops B1 and B2 start to operate preventing the system from growing. A higher weight in the variable team self-confidence will lead to an initially lower build up of psychological safety. Once the reinforcing loops R1 and R2 start to operate in the virtuous direction, there will be an increase in the growth rate until learning reaches a maximum level sustained by the psychological safety level that the team experiences. The actual level of team performance will outweigh the desired level.

The results of the simulations highlight the idea that the role of team leader coaching should be revised and more emphasis should be given to preparing team members to work interdependently and proactively, and to be part of the decision process.
Figure 26: Comparing the Impacts of Leader Coaching and Self-Confidence on Psychological Safety

Figure 27: Comparing the Impacts of Leader Coaching and Self-Confidence on Team Performance
**Normal Level of Psychological Safety (Context Support)**

The *normal level of psychological safety* represents the level of safety that an adequate organizational context should provide for teams to engage in learning-oriented activities. In the base case, this constant was set at the maximum level of 1. The simulations show that there is a theoretical minimum level of normal level of psychological safety (representing context support) that will sustain the engagement of teams in learning-oriented activities. Such level, however, must be higher than the level of "learning anxiety" produced by learning initiatives. Defining the level of learning anxiety and overcoming it is a key issue for the success of a learning initiative. The simulations show a minimum level of 0.8 to trigger the reinforcing loops R1 and R2, learning behaviors, so that learning could have a positive impact on team productivity and performance could reach the manager's goal.

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**Figure 28: Impact of Normal Level of Psychological Safety on Indicated Performance**

![Graph showing impact of normal level of psychological safety on indicated performance](image)

- **Indicated Task Completion Rate**: base case ——— 1 task/month
- **Indicated Task Completion Rate**: low context support (0,2) ——— 2 tasks/month
- **Indicated Task Completion Rate**: average context support (0,5) ——— 3 tasks/month
- **Indicated Task Completion Rate**: high context support (0,85) ——— 4 tasks/month

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Figure 29: Impact of Normal Level of Psychological Safety on Team Safety

Psychological Safety: base case
Psychological Safety: low context support (0.2)
Psychological Safety: average context support (0.5)
Psychological Safety: high context support (0.85)

Figure 30: Impact of Normal Level of Psychological Safety on Learning Behaviors

Effect of D and D Practice: base case
Effect of D and D Practice: low context support (0.2)
Effect of D and D Practice: average context support (0.5)
Effect of D and D Practice: high context support (0.85)
Conclusion

The sets of simulations presented in this section buttress the importance of learning behaviors on team performance. Psychological safety has a great impact on the team's engagement in learning-oriented activities. Mental models, as well as fears and anxieties, should be carefully examined and rethought so that a sense of trust and motivation can arise to facilitate team members' commitment. Self-confidence demonstrated to be relevant in the dynamics of team learning. On the tangible side, access to resources and information as well as a supportive and skillful leader should be in place to support and motivate the team.
Chapter Five

Discussion

"Team learning is the most challenging discipline -- intellectually, emotionally, socially, and spiritually."

(The Fifth Discipline Fieldbook, p.355)

Team learning is a fundamental dynamic step on the path of organizational learning. In this thesis I tried to develop a deeper understanding of the influences of learning behaviors and their antecedents on the performance of work teams. The simulation model and the simulation results highlighted a number of implications of the theory outlined.

First, performance goals play a fundamental role in driving the dynamics of the system. Researchers on organizational learning argue that team goals and norms should be clearly defined since they influence the functioning and effectiveness of teams. However, researchers say little about the levels at which performance goals should be set. The simulations show that less aggressive goals are favorable because they lead to less expectations and more positive evaluations and consequently to better performance results. Positive evaluations positively affect team self-confidence, increasing the level of psychological safety and thus leading the team to a growing engagement in learning-oriented activities. One may argue that low performance goals may predetermine low performance, leading the team to perform below its optimal level. However, as the simulations show, setting high performance goals has its costs and presents no benefits.
Moreover, high performance goals are likely to operate as limits to growth. To avoid such resistance in the system, performance goals should be set at an efficiently lower level to produce favorable evaluation results and still generate a gap that motivates team members to engage in learning behaviors. Therefore, I argue that performance goals function as a motivation to team learning and should be clearly addressed by the model of team learning.

Second, the normal level of psychological safety, or context support, has proved to play an important role in providing a supportive environment, adequate resources as well as reward systems, and access to information, so that teams can perform their tasks more effectively (Ancona et al., 1996; Edmondson 1996,1999; Hackman, 1983). The model simulations corroborate such predictions and add that there is a minimum theoretical level of normal psychological safety that will foster and sustain team learning. This level, however, must be higher than the level of "learning anxiety" (Schein, 1992) produced by learning initiatives.

Third, it is undoubtedly the case that the team leader plays a key role within the team. A set of simulations conducted in Chapter Four reinforces this prediction. However, another set of simulations shows that too much emphasis on the team leader can hinder team learning rather than foster it. This happens because team members might become so dependent on the leader for help or coaching that once the leader stops coaching or helping the team proactively, whatever the reasons, the level of team psychological safety as well as learning and performance will suffer. The model suggests that more emphasis should be given to team self-confidence to mitigate the consequences of possible poor leadership. In her study
of low and high performing teams, Edmondson (1996, 1999) studied seven teams in order to better understand how they function as teams. Except for two teams (one low- and one high-performing), the other teams confirmed her model in which team leader coaching is associated with psychological safety. By presenting these examples, I do not intend to challenge her model, but to shed light on the implications that self-confidence has on psychological safety. The low-performing team has adequate context support and a leader who, although located in an office distant from the team, tries to coach and help team members to improve. However, there is too much conflict among team members who question each other's competence and behavior. Such lack of synergy is likely to be caused by a low level of self-confidence among them. Self-confidence causes people to feel that they are effective and have success in designing and implementing their actions. As Argyris points out, they will enter a situation with a greater degree of certainty that they can behave competently. This feeling of competence can be observed in the high-performing team which also has an adequate context support. Contrary to their leader who has a passive style, team members are energetic and proactive and express mutual respect. This team presents a high level of self-confidence that mitigates the effect of a lack of coaching and leader motivation. The results of the simulations, together with the examples presented above, highlight that the role of team leader coaching should be revised and more emphasis should be given to preparing team members to work interdependently and proactively, and to be part of the decision process.
The three implications presented above led me to draw a parallel between Schein's theory of organizational learning and the variables that drive the behaviors of the system. As discussed in Chapter Two, Schein presents three conditions for learning to take place, to which I linked my findings from the simulation model.

<table>
<thead>
<tr>
<th>Schein's conditions to learning</th>
<th>Simulation model implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disconfirming data</td>
<td>Unexpected results from performance evaluations</td>
</tr>
<tr>
<td>Anxiety and/or guilt</td>
<td>Gap between desired performance and actual performance</td>
</tr>
<tr>
<td>Enough psychological safety</td>
<td>Normal level of psychological safety (context support) + Self-confidence</td>
</tr>
</tbody>
</table>

Unexpected results from performance evaluations will create a disequilibrium in the system once the performance goals have not been reached. The gap between the desired performance and the actual performance of the team will reinforce the disconfirming data and generate enough anxiety to motivate the team to learn or change. The normal level of psychological safety (or context support) coupled with a well-developed degree of self-confidence within the team will create enough psychological safety to support the team in their learning journey.
Future work could build on this study in a number of ways. First, the model developed here can be challenged and improved. I have drawn my work on one model of team learning and on supporting theory. Thus, alternative theories can shed light on this work and a way to do so is through alternative formulations based on contrasting organizational theory. Second, the simulation model can be expanded to include other feedback loops. There are numerous factors that affect team learning and performance in the organizational set that can be represented in the model. Factors and mechanisms affecting internal team functioning could be studied and incorporated into the model. Finally, field research can be conducted to further analyze the role of less aggressive performance goals, as well as the role of self-confidence and their consequences on team learning, and empirical data can be eventually compared to those offered by the simulation model.
References


Appendix

*Parameters Assumptions - The Base Case*

Effect of Team Self Confidence = Confidence function(Perceived Performance)
Units: dimensionless

Leader skills = 1
Units: dimensionless

Introducing tasks = 1
Units: tasks/month

Indicated Psychological Safety = Normal level of psychological safety*((Effect of Team Self Confidence*W1+Team Leader Coaching*W2)/(W1+W2))
Units: dimensionless

Initial fraction of Psyc Safety = 0.6
Units: dimensionless

W2= 0.4
Refers to the weight that leader coaching has on the building of psychological safety.
Units: fraction

W1= 0.6
Refers to the weight that Self-confidence has on building psychological safety
Units: fraction

Discussion and Dialogue Practice = Psychological Safety * maximum discussion
Units: conversation/month

Relative Discussion = Discussion and Dialogue Practice/maximum discussion
Units: fraction

"Building psyc.safety"=
(Indicated Psychological Safety-Psychological Safety)/Time to gain or lose safety
Units: dimensionless/month

Effect of D and D Practice = D and D function(Relative Discussion)
Units: dimensionless

Psychological Safety = INTEG ("building psyc.safety", Initial fraction of Psyc Safety)
Units: dimensionless

Indicated Task Completion Rate =
Team Productivity*(1-fraction of time lost in conversation)
Units: tasks/month

Indicated team productivity =
Minimum Productivity*(1+(Effect of D and D Practice * Feedback Practice))
Units: tasks/month

Feedback Practice = SMOOTH("Psyc.Safety Effect on Feedback",time to get feedback)
Units: dimensionless

Effect of Team Leader Coaching = Coaching function(Perceived Performance)
Units: dimensionless

Normal level of psychological safety = 1
Units: dimensionless

Time to get feedback = 1
Units: month

Team Leader Coaching = Effect of Team Leader Coaching * Leader skills
Units: dimensionless

Perceived Tasks being completed =
SMOOTH(completing tasks, Time to perceive performance)
Units: tasks/month

Perceived Performance = Perceived Tasks being completed/Desired Tasks Completion Rate
Units: dimensionless

Time to perceive performance = 12
Units: month

Completing tasks =
Min(Indicated Task Completion Rate,Tasks/Minimum Time to complete task)
Units: tasks/month

Minimum Time to complete task = 10
Units: month

Minimum Productivity = 0.075
Units: tasks/month

Learning how to be more productive =
(Indicated team productivity - Team Productivity) / Time to Learn
Units: tasks/month/month

Maximum discussion = 8
Units: conversation/month

Fraction of time lost in conversation = D and D impact on Tasks / Hours of work per month
Units: fraction

Hours of work per month = 176
Units: hours/month

D and D function = ([0, 0] - (1, 1)), (0, 0), (0.0936556, 0.0219298), (0.18429, 0.0570175),
(0.274924, 0.0921053), (0.371601, 0.179825), (0.453172, 0.328947), (0.5, 0.5), (0.63142, 0.789474),
(0.740181, 0.9210), (0.848943, 0.964912), (1, 1))
Units: dimensionless

Time per conversation = 1
Units: hours/conversation

D and D impact on Tasks = Discussion and Dialogue Practice * Time per conversation
Units: hours/month

"PsycSafety Effect on Feedback" = Feedback function (Psychological Safety)
Units: dimensionless

Coaching function
= ([0, 0] - (1, 1)), (0.060423, 0.77193), (0.108761, 0.763158), (0.23565, 0.745614), (0.332326,
0.666667), (0.652568, 0.342105), (0.746224, 0.263158), (0.870091, 0.223684), (0.996979, 0.219298))
Units: dimensionless

Tasks = INTEG (+introducing tasks - completing tasks, 0)
Units: tasks

Tasks Completed = INTEG (completing tasks, 0)
Units: tasks

Time to gain or lose safety = 2
Units: month
Feedback function
([[(0,0)-(1,1)],(0,0),(0.108761,0.0175439),(0.18429,0.0350877),(0.247734,0.0745614),
(0.317221,0.140351),(0.377643,0.25),(0.5,0.5),(0.622356,0.77193),(0.697885,0.885965),
(0.779456,0.934211),(0.848943,0.969298),(1,1),(1,1)])
Units: dimensionless

Time to Learn = 2
Units: month

Confidence function
([[(0,0)-(1,1)],(0.00302115,0.114035),(0.114804,0.144737),(0.223565,0.188596),
(0.338369,0.289474),(0.5,0.5),(0.731118,0.767544),(0.818731,0.859649),(0.897281,0.899123),
(1,0.907895)])
Units: dimensionless

Team Productivity = INTEG (learning how to be more productive, Minimum Productivity)
Units: tasks/month

Desired Tasks Completion Rate = 0.1
Units: tasks/month

*********************************************************************************************
Control
*********************************************************************************************
Simulation Control Parameters

FINAL TIME = 60
Units: month
The final time for the simulation

INITIAL TIME = 0
Units: month
The initial time for the simulation

SAVEPER = TIME STEP
Units: month
The frequency with which output is stored

TIME STEP = 0.125
Units: month
The time step for the simulation