Goal setting, evaluation, learning and revision: A dynamic modeling approach

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Abstract

Learning in organizations (or individuals) interacts in important ways with organizational goal dynamics. Most organizations seek specific explicit or implicit goals. In the simplest computer-simulation models of goal-seeking in organizations, there is a constant goal and the model captures the dynamic difficulties involved in reaching that given goal. In more sophisticated models, the goal itself is variable. The goal can erode as a result of various phenomena such as frustration due to persistent failure; it can evolve further as a result of confidence caused by success; or, it can be evaluated and adjusted periodically as a result of some formal process. Goal evaluation and goal setting are important elements of the continuous learning cycle in organizations. With respect to goal dynamics, there are models of limited and linear goal erosion dynamics. We extend existing models by including organizational capacity limitations on performance improvement rates and non-linear interactions in goal erosion. Our model offers a general theory of goal formation in individuals as well as organizations, including potential goal erosion, caused by persistent poor performance, as well as positive goal evolution dynamics, as a result of consistent success. The model supports the notion that successful strategies involve learning about goal-performance interactions.

Keywords: Goal dynamics; Goal erosion; Goal evaluation; Goal evolution; Goal formation; Goal setting strategy; Organizational learning; Performance evaluation; Simulation; Systems modeling

Goal planning and setting is crucial to performance improvement in organizations as well as in individuals (Ericsson, 2001; Lant, 1992; Schalock & Bonham, 2003). Most performance improvement activities consist of the following cycle: set a goal, measure and evaluate current performance against the goal, take actions to improve performance, evaluate and revise the goal if necessary, again measure and evaluate performance against the current goal, and so on (Lant, 1992; Senge, 1990; Sterman, 2000). Goals constitute a base for the decisions and the managerial actions. In an organization, the performance level is evaluated against a goal and, further, the effectiveness of the goal itself can and should be periodically evaluated. Among various research methods to analyze the dynamics of goals in organizations (and individuals), an important one is simulation modeling—more specifically system dynamics modeling that is particularly suitable to model qualitative, intangible and ‘soft’ variables involved in human and social systems (Morecroft & Sterman, 1994; Spector, Christensen, Sioutine, & McCormack, 2001; Forrester, 1994; Sterman, 2000).

System dynamics is a methodology for modeling, analyzing and improving dynamic socio-economic and managerial systems, using a feedback perspective. Dynamic strategic management problems are modeled using mathematical equations and computer software and dynamics of model variables are obtained by using computer simulation (e.g. Barlas, 2002; Forrester, 1961; Sterman, 2000).

The span of applications of the system dynamics field includes: corporate planning and policy design, public management and policy, micro and macro economic dynamics, educational problems, biological and medical modeling, energy and the environment, theory development in the natural and social sciences, dynamic decision making research, strategic planning and more (Ford, 1999; Forrester, 1961; Morecroft & Sterman, 1994; Roberts, 1981; Senge, 1990; Sterman, 2000). Since these problems are typically managerial-policy oriented, structures that deal with goal dynamics play an important role in most system dynamics models (e.g. Barlas, 2002; Forrester, 1961; Sterman, 2000). It is therefore no

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There are different aspects of goal dynamics, at different levels of complexity. The most fundamental notion and a building block used in most policy models is a goal seeking structure that represents how a certain condition (or state) is managed so as to achieve a given goal (see Fig. 1). For instance, the state might be the inventory level or delay in customer service, and the goal might be an optimal inventory level or an acceptable service delay. Management would then take actions to bring the states in question closer to their set goal levels (see Forrester, 1961; Sterman, 2000 for diverse examples). A more sophisticated and realistic goal-related structure is called a floating goal structure. In this case the goal is not fixed; it varies up and down depending on current conditions (Senge, 1990; Sterman, 2000). If the performance of the system is persistently poor in approaching the originally set goal, then the system implicitly or deliberately lowers the goal; this is a case of eroding goal. If on the other hand, the system exhibits surprisingly good performance, then the goal is pushed higher; this is a case of evolving goal. These movements up and down may be deliberate as a result of structured formal evaluation or learning activities, or these movements may represent unconscious forms of learning. Thus, the topic of goal evaluation and setting is an important research topic in individual and organizational learning (Ericsson, 2001; Lant & Mezias, 1992), as well as system dynamics modeling (Morecroft, 1983; Sterman, 2000).

A key component of a general goal setting structure is expectation formation. Goals are set and then adjusted in part as a function of future expectations (Lant, 1992; Sterman, 1987). This may involve expectations of management, expectations of participants or both. Formulation of expectations is a rich research and modeling topic with its roots in cognitive research in policy making (Spector & Davidsen, 2000) and rationality, ranging from rational expectations to satisficing and bounded rationality (Morecroft, 1983; Simon, 1957).

Goal dynamics and associated components (e.g. performance measurement, expectation formation, goal setting, goal evaluation, goal erosion or evolution) may play important roles in the design, planning and evaluation of improvement programs. For successful organizational improvement programs, performance measurement, goal evaluation and goal planning are critical activities (see Newcomer & Neill, 2001; Schalock & Bonham, 2003). We present a comprehensive goal dynamics model and show how this model can shed light on subtle issues in improvement program planning and evaluation. We argue that an understanding of goal dynamics—especially goal evaluation, expectation formation, and goal setting and revision—is important in furthering the research and practice of organizational learning. This is true because goal dynamics involves different forms and levels of learning. Senge (1990) discusses various types of organizational goals, goal dynamics and their relation to organizational learning. An even more explicit use of system dynamics modeling in organizational learning is sometimes called modeling for learning (Morecroft & Sterman, 1994; Spector, Christensen, Sioutine, & McCormack, 2001).

The modeling setting assumed herein is an organization in which a new performance goal is set and a new program (e.g. a training activity) is started to achieve the goal. In a service company, this may be a new training program set to increase the customer satisfaction from 60 to 80% in one year as measured by a series of customer surveys. In a public project, this may be a new educational program in a low income neighborhood set to increase the functional literacy rate from 80 to 90% in three years as measured by periodic tests. Our comprehensive model suggests a general theory of goal dynamics, so that it is applicable to both of these two different example settings with only minor parametric adjustments.
We begin by discussing the simplest model of constant goal seeking dynamics as a background. We then add a series of more realistic and complex goal related structures to the initial model. The purpose of each addition is to introduce and discuss a new aspect of goal dynamics in increasingly realistic settings. In the first enhancement, we introduce how the implicit goal in an organization may unconsciously erode as result of strong past performance traditions. In the second enhancement, we include the effects of time limits on performance and goal dynamics. Some improvement programs have explicitly stated time horizons and the pressure (frustration) caused by an approaching time limit may be critical in the performance of the program. We show that in this more realistic environment, the proper level of goal setting and the implicit short-term self-evaluation horizons of the participants may be very critical in determining the success of the improvement program. We continue with an adaptive management policy that is designed to assure the success of a program by taking into consideration the potential sources of failure revealed by our model. We conclude with observations on implementation issues, implications for organizational learning and further research suggestions.

1. A simple goal seeking model and dynamic behavior

In the simplest goal structure, there is just one fixed goal for each performance level. Once the goal is set, it is not challenged by the internal dynamics of the system or by any external factors. Such a model can be seen in Fig. 1. In the model, the fundamental state (condition) that is being managed for improvement is called the performance level, represented as a ‘stock’ variable. There are two main forces (represented by flow variables) influencing the performance level stock: a force (performance improvement) that improves the performance level and another force (performance loss) that deteriorates it. Performance improvement rate is the main result of some training program and this rate is limited by some maximum capacity. The utilization factor tells what percent of the maximum improvement capacity is utilized at a moment. This utilization is naturally not constant, being dependent on where the system stands compared to the set goal. Performance loss is assumed to be simply a fraction (performance loss fraction) of the actual performance level. This means in essence that due to rapidly changing hi-tech organizational setting, the performance level tends to decay over time, if no improvement training is undertaken. Performance loss rate also has a limit, namely maximum performance loss.

Improvement Capacity, the maximum possible improvement rate, is a constant in our models, as ‘capacity management’ is beyond the scope of this paper. The Stated performance goal set by the top management, in this simple model, is assumed to be equal to the ideal performance goal, defined as the ideal level that the system is expected to achieve in the long term. We choose maximum performance loss to be less than capacity, otherwise it would be impossible to ever fulfill the ideal performance goal, which would contradict our very own definition of the Ideal goal. Utilization of capacity is a function of Effect of desired performance improvement and Effect of motivation, and all three variables take values between 0 and 1. So in a nutshell, the higher the desired performance improvement, the higher is utilization of the improvement capacity, until a limit is reached. In this first introductory model, effect of motivation is assumed equal to one, so it does not have any influence on the dynamics. But, it will have an important role later in the improved versions of the model.

The rest, desired performance improvement formulation is the ‘anchor-and-adjust’ formulation (Barlas & Ozervin, 2004; Sterman, 1989, 2000; Yasarcan, 2003; Yasarcan & Barlas, 2005) standard in most goal seeking models: It is formulated as estimated performance loss plus performance adjustment (discrepancy between Stated performance goal and the performance level divided by performance adjustment time). It is said that the improvement decision uses estimated performance loss as an anchor and then adjusts the decision around it, depending on the discrepancy between the performance goal and current performance level. Since, it is not possible to know the performance loss immediately and exactly, performance loss must first be estimated by the decision maker or system participants (see Fig. 1). Expectation formation used in this simple estimation formulation is a very simple example of learning in organizations. Estimation formation time represents the delay in learning the actual value of performance loss that is dynamic, which means that the learning process is continuous.

Dynamic behavior generated by simulating the model of Fig. 1 can be seen in Fig. 2. The behavior observed is called ‘goal seeking behavior’ in the system dynamics literature. Performance level (line 2 in Fig. 2) gradually seeks the Stated performance goal. The performance improvement rate is above the performance loss rate, the performance level keeps increasing until it reaches the stated goal, at which point the performance improvement is lowered down to the performance loss rate, since the goal is reached. This model is too simple, being basically of introductory pedagogical value. The model can only explain simple goal seeking dynamics such as shower temperature adjustment or a water tank filling up to a desired level. We introduce a series of realistic enhancements to the model in the following sections.

2. Goal erosion

Goal erosion model (Fig. 3) is more realistic and complex version of the simple goal seeking model. In cases of goal erosion, there is an endogenous, system-created, undeclared, implicit goal (implicit performance goal) that the system seeks instead of an explicitly set goal (stated performance goal).

In Fig. 3, there are two new important variables (compared with the model in Fig. 1): traditional performance and implicit performance goal. Traditional performance (Forrester, 1975) represents an implicit, unconscious learning process in the system. The first, more explicit learning was represented as estimated performance loss. The human participants in the system gradually form a belief about their own performance
level as time passes and this learned performance (traditional performance) starts to have more effect than the stated performance goal. The accumulation of such individual beliefs creates a shared belief in the system that the realistic performance goal of the system should be somewhere around this average past performance. To represent this mechanism, we assume that the system creates its own goal called implicit performance goal and seeks this new goal instead of the managerially stated performance goal (see Fig. 6 for the main feedback loop in action).

We assume that in a new improvement program, in the beginning there is no information about past performance, so the human participants in the system blindly accept the Stated performance goal as its goal to seek. As time passes, traditional performance starts to have bigger effect and the Implicit performance goal starts approaching the traditional performance instead of staying at the managerial (stated) goal, a phenomenon often called ‘goal erosion’. Note that the performance level starts to follow the implicit performance goal, not the Stated performance goal. The dynamic behavior of goal erosion can be as seen in Fig. 4.

In the scenario represented in Fig. 4, we assume that the traditional performance formation time is moderate (i.e. there is a moderate past tradition effect), so traditional performance
lags somewhat behind the current performance level. The goal erosion is caused by the fact that as the performance level tries to seek the implicit performance goal, the implicit performance goal itself gradually approaches (or erodes toward) the traditional performance level. As a result, the performance seeks a goal that is continuously eroding toward the past average performance (traditional performance). As can be seen in Fig. 4, the implicit performance goal may erode toward traditional performance and to the point of even crossing below the current performance level, since it is the delayed traditional performance that determines the implicit performance goal. Erosion can be even more extreme than the one shown in Fig. 4 if there is very strong past tradition, represented by a very long traditional performance formation time in the model.

2.1. Goal erosion, time pressure, frustration effects and possible recovery

The two introductory models (Figs. 1 and 3) are simple in the sense that they do not include important psychological effects (motivation, frustration, tension, etc.,) discussed in the literature. ‘People find the tension created by unfulfilled goals

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Fig. 4. Eroding goal behavior under the influence of traditional performance belief (bias).

Fig. 5. The structure of a comprehensive goal formation model.
uncomfortable and often erode their goals to reduce cognitive dissonance’ (Sterman, 2000, p.532). The implicit performance goal may erode if there is a belief in the system that to reach the set goal (stated performance goal) is hard or impossible, but it may recover if the belief is positive. The simple models mentioned above, either capture constant goal seeking behavior or uniform goal erosion (Senge, 1990; Sterman, 2000). But they are not rich enough to be able to generate more realistic and complex dynamics, such as goal erosion-then-recovery or goal seeking-then-erosion.

In this research, we propose a more general and comprehensive model for goal dynamics (Fig. 5). In the new model, just like the previous model of Fig. 3, the system creates its own internal implicit performance goal and seeks this new goal instead of the managerially stated performance goal. The fundamental negative (or goal-seeking) feedback loop that drives the performance level towards implicit performance goal is shown in Fig. 6. This generic negative feedback loop whereby some state is gradually driven towards its goal is fundamental in systemic dynamic models and used in several other sub-structures in our models (for instance, expectation formation is also a negative loop, such as perceived performance gradually estimating the current performance level, or the traditional performance being a time-delayed estimate of the performance level). One of the new features of the new model is that implicit performance goal is now seeking neither stated performance goal nor traditional performance alone, but it seeks a weighted average of the two (Forrester, 1961; Sterman, 2000). Specifically, it is formulated as: weight × stated performance goal + (1 – weight) × traditional performance. The weight thus determines how much the system believes in stated performance goal, and this belief itself (i.e. the weight) is variable, depending on the internal motivations of the participants. We model this weight as a joint increasing function of two motivation components: Accomplishment motivation and short term motivation. (see Fig. 5). Accomplishment motivation is a factor that represents the participants’ belief that the stated performance goal is achievable within the program time horizon.

The program time horizon is set as 500 days in the following simulation runs. Thus, the participants compare their estimated performance improvement rate with the time left and their Accomplishment motivation goes up, if they believe that the stated performance goal is achievable (Figs. 5 and 6). The second component of motivation has to do with the participants’ their own intrinsic short term horizon, (assumed to be 20 days). The assumption is that participants judge their own performance over a 20 days horizon and if they are satisfied (meaning high short term motivation), then they give more weight to the stated performance goal, otherwise they lower this weight (implying that the weight of their traditional performance increases). Thus, the potential erosion of the implicit performance goal depends on the dynamics of the short and long term accomplishment motivations of the participants.

Finally, the time horizon of the improvement program plays a second critical role: as the time limit approaches, if participants realize that there is no way they can even approach the stated goal within the time horizon, their accomplishment motivation collapses and they sharply lower their ‘capacity utilization’. We call this ‘giving up’ dynamics in the following simulations. This positive feedback loop may cause either ‘giving up’ (vicious cycle), or if it works in the right direction, an exponentially growing performance (virtuous cycle), as shown in Fig. 6.

As will be seen below, where the stated performance goal is set turns out to be critically important in this new model. The dynamics for two different values of stated performance goal are plotted in Figs. 7 and 8. If the stated performance goal is too high (for instance 400) relative to the current state (initially 100), there will be a disbelief in the system that the stated goal is reachable. This disbelief will result in de-motivation in the short/medium term, which further causes the Weight of stated performance goal to reduce down and the implicit performance goal erodes. This is the initial dynamics in Fig. 7. After this initial eroding goal behavior, we observe a mild goal (and performance) recovery between days 100 and 200. Performance is sustained at some level for some duration of time. But then, the system participants recognize that the remaining time to accomplish the stated performance goal is impossibly too short, which results in ‘giving-up’ behavior and improvement activity eventually collapses (Fig. 7, second half). So in Fig. 7, three different stages of goal dynamics can be observed: eroding goal behavior, goal (and performance) recovery, and finally giving up behavior.

In the simulation experiment of Fig. 8, the stated performance goal is low enough to create a success: the goal is reached in the given time horizon. The brief initial erosion due to the initial gap between the stated performance goal and initial performance level still exists, but the stated performance goal in this case is low enough to create and sustain motivation, to improve performance level towards this goal and achieve it.

![Fig. 6. The Performance level seeks the implicit performance goal, via performance improvement (the basic inner goal-seeking loop). Simultaneously, the Perceived performance relative to time horizon determines the accomplishment motivation which in turn affects the performance improvement (the outer reinforcing loop).](image-url)
Yet, how can a manager know the ‘correct level’ of the stated performance goal? Furthermore, what if this level of performance is too low (conservative) compared to the true improvement potential of the system?

Forrester (1975, p.168) states: ‘The goal setting is then followed by the design of actions which intuition suggests will reach the goal. Several traps lie within this procedure. First, there is no way of determining that the goal is possible. Second, there is no way of determining that the goal has not been set too low and that the system might be able to perform far better. Third, there is no way to be sure that the planned actions will move the system toward the goal’.

Our comprehensive model (Fig. 5) is designed to illustrate these issues by simulation experiments. As a result of these experiments, we conclude that solution to the above problems necessitate ‘dynamic and adaptive goal setting’ strategies by the management, as addressed in the Section 2.2.

2.2. Proper management policy to maximize the performance improvement

We suggest that to obtain a successful performance improvement, the stated performance goal must be managed dynamically and adaptively. The management must continuously monitor the performance level and must evaluate its level and its trend. The stated performance goal must be then set realistically within the bounds of a ‘reachable region’, which is a function of the performance level and its trend (net improvement rate). If the performance level is improving, stated performance goal must also be gradually moved up to guide and motivate the improvement activities. If the

Fig. 7. After initial erosion, performance level temporarily recovers, but eventually exhibits giving-up behavior due to time limit. (stated performance goal = 400).

Fig. 8. If stated performance goal is low enough, sustainable recovery is possible. (stated performance goal = 350).
performance level is stagnating, this means that the stated performance goal is unrealistically high, so it must be lowered till there is a sign of sufficient improvement in the performance level. Our enhanced model is designed to implement and test such an adaptive management strategy (the model details are skipped in this article; see Yasarcan, 2003).

In Fig. 9, a successful adaptive management of dynamic stated performance goal is illustrated, leading to maximum organizational success where the ultimate ideal performance goal is eventually achieved. The initial value of stated performance is set deliberately high (just 10% below the ideal performance goal) to show how the adaptive management strategy immediately senses the infeasibility of the initial goal level and lowers it down. Once stated performance goal becomes close enough to the performance level to motivate the participants, sustained performance improvement is obtained (Fig. 9, after about day 50). From this point on, the adaptive strategy continuously and gradually moves the goal up, so that eventually the ideal goal (1000) is attained before the program time limit (500 days) is reached.

Recall that with the previous constant stated performance goal strategies, if the time horizon is too short (compared to the set goal), the eventual dynamics is always a collapse due to giving up behavior. We finally test this condition with our adaptive strategy: What happens if time horizon is too short and our adaptive goal setting strategy is used? To answer this question, we halve the time horizon down to 250 days and keep all else unchanged in the model. The result is instructive: even though the ideal performance goal is out of reach in the given time horizon, our approach still creates a satisfactory performance improvement, without any erosion or eventual giving-up behavior. The performance level consistently improves and eventually settles down at a level that is apparently the best that can be realistically achievable within

Fig. 9. A successful result with dynamic stated goal management (initial stated performance goal = 900 and time horizon = 500).

Fig. 10. Dynamic stated goal management with shorter time horizon. (initial stated performance goal = 900 and time horizon = 250).
the short term horizon (Fig. 10). We thus submit that our adaptive dynamic goal setting policy can constitute a useful framework for successful management of goal-directed improvement programs.

3. Concluding observations

This article is expected to show that some subtle and complex dynamics of goal setting and goal seeking can be discussed by means of dynamic modeling and simulation experiments. A series of models replicate a series of goal dynamics observed in real organizations, ranging from simple (constant) goal seeking, to uniform goal erosion to erosion-then-recovery and finally to erosion-then-recovery-then collapse. We show that goal-seeking organizational improvement activities can exhibit very subtle problematic dynamics in such cases. We also discuss the conditions and mechanisms behind each dynamics.

We propose a most general model (theory) of goal dynamics, by including organizational capacity limitations on performance improvement rate and rather general non-linear structures of goal erosion. The model is general in the sense that it offers a generic theory of goal formation in individuals as well as organizations; including potential goal erosion (caused by persistent poor performance) as well as positive goal evolution dynamics (as a result of consistent success). We finally propose an adaptive managerial goal setting strategy and test it by simulation experiments. We show that the successful strategies are the ones in which ‘adaptive learning’ about goal and performance dynamics can be said to have taken place. For success, productive learning must take place on two sides: in management and in system participants.

Our theoretical model and management strategies can be implemented to specific improvement program settings, by proper adaptation of the model structures and calibration of parameters. The suggested dynamic goal setting policy can constitute a useful framework for successful management of goal-directed improvement programs. Our models can also be turned into interactive simulation games, microworlds and larger learning laboratories so as to provide a platform for organizational learning programs. In parallel, our models may provide useful starting points for different research projects on goal setting, performance measurement, performance improvement management, evaluation, and learning.

References


