A dynamic system simulation of leader and group effects on context for learning

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Abstract

The dynamic interactions of leaders and followers often result in important strategic resources and competencies that are critical to an organization’s success. Yet there is little research that explicitly addresses how the skill levels of leaders and followers are linked as a socially constructed strategic resource is created. This article describes an agent-based dynamic model simulation of the creation of Group Context-for-Learning, which is an intangible strategic resource that supports organizational learning. The simulation describes developmental paths showing the growth in Group Context-for-Learning for various leader–group combinations. While both leader and workgroup skill levels affected the developmental paths shown by different groups, a highly skilled group invariably produced a better developmental path than a low skilled group, regardless of the leader’s skill level.

Keywords: Agent-based simulation; Leadership; Change

Leaders and followers both play important roles in the development of strategic organizational resources and competencies (Sanchez & Heene, 1997). The continuous process of leader–follower interaction warrants consideration in the development of socially constructed strategic resources. Leader–follower interactions are complex and are characterized by reciprocal influence, as well as time and context sensitivities that can affect the outcomes of the interactions (Giddens, 1977). Socially constructed strategic resources (such as a favorable Context-for-Learning) may be affected by a leader’s skills, follower’s skills and/or the combined effects of both, especially when considering the dynamics of the interactions over time.

Because of these issues and the fact that followers learn through remembered experiences, traditional empirical research methods (including rotational designs) may be inadequate to determine which leader style best suits the development of a strategic resource. Some researchers have addressed the problems of reciprocal influence, time, and context sensitivity by examining social networks and demographics of strategic leaders; others have used qualitative research methods (Carpenter & Westphal, 2001; Gronn, 1999; Hunt & Ropo, 1992; Mumford & Van Doom, 2001). While these researchers recognize that social dynamics can generate strategic resources, there has been a lack of focus in strategic leadership research on the specific social dynamics from which strategic resources can emerge (Priem, Lyon, & Dess, 1999).

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In this research, we have applied one of the most popular and powerful quantitative tools of complex system analysis—computational modeling (Carley, 1995). We applied this tool to help understand the dynamics involved in the leader’s role in developing strategic competencies. Our model provides insight into the complex processes of workgroups in organizations in generating a strategic resource. Specifically, we modeled the impact of a leader’s role behaviors on individual followers in a workgroup context as a socially constructed strategic resource is created. Leader role behaviors are modeled using Quinn’s Competing Value Framework (Quinn, Faerman, Thompson, & McGrath, 2003). This framework includes behaviors that others have indicated are management oriented as well as those that have been identified as leadership oriented (Bedeian & Hunt, in press), and is consistent with our view that the two are complementary (Bass, 1985; Kotter, 1990; Quinn, 1988). The socially created strategic resource that we examined is the Context-for-Learning (CFL), which is a strategic competence that both individually and collectively supports organizational learning (Black & Boal, 1997; Black, King, & Oliver, 2005; Ghoshal & Bartlett, 1994).

The CFL is a measure of an individual’s perception of his/her ability to learn within his/her organization. The Group Context-for-Learning (GCFL) is the collective perception by a group of the members’ ability to learn within an organization. GCFL is important in order for groups to demonstrate a capacity to change and a high level of performance (Black & Boal, 1997). The effects of follower–leader–group dynamics on the development of CFL have been addressed and modeled elsewhere (Black et al., 2005). While certain elements of CFL were found to be related to the leader, specific leader behaviors influencing the context over time were not studied. The research reported here combines Quinn’s Competing Values Framework (CVF) and CFL to model the influence of leader’s role behavior on individuals and groups over time.

1. Quinn’s competing values framework

Quinn and associates analyzed effective management from a competing value perspective (Denison, Hooijberg, & Quinn, 1995; Quinn, 1984, 1988). Their model identifies four general competing values and associated roles (see Fig. 1). Control Value Systems compete with Flexibility Value Systems and Internal Focused Value Systems with External Focused Value Systems. These competing values require a leader to take on different roles with attendant different behaviors—Mentor, Facilitator, Monitor, Coordinator, Innovator, Broker, Producer and Director. The roles and associated behaviors are complementary within a single quadrant and contrast directly with the roles in the opposite quadrant (Fig. 1) (Quinn et al., 2003). Patterns of skill levels in the various roles were identified as archetypical leader profiles (Quinn et al., 2003). Eight such archetypical leader profiles were suggested by Quinn et al. (2003), half of which were identified as effective and half as ineffective.

Competing Values Framework (CVF) questionnaires help diagnose an individual’s leadership roles by assessing the level of skill for behaviors associated with the roles and the frequency with which each behavior is used. The CVF questionnaires have demonstrated discriminant, convergent and nomological validity (Denison et al., 1995). Effective leaders are associated with effective individual leader behaviors for the different roles and the perception by followers that the leader is effective (Bullis, 1992; Hart & Quinn, 1993; Hooijberg, 1996). Quinn et al. noted that there was a
tension involved in the learning of behaviors associated with competing roles. He suggested that for a pair of competing roles that once one had high skill levels in the behaviors associated with one role it was more difficult to improve the skill levels of the behaviors associated with the opposite role (Quinn et al., 2003).

2. The context-for-learning competence

Beyond having the skills associated with the leadership roles, leaders strive to create specific strategic resources and competencies for their organizations. We chose to examine the development of the Context-for-Learning (CFL) competence (a firm level equivalent of an individual competence) because of the high rate of change in our business environments and the way we carry out our work (Harrigan, 2001). This condition requires employees who continuously learn (Harrigan, 2001; Quinn, 2002; Winter, 2003). The purpose of the CFL competence is to support this learning.

Ghoshal & Bartlett (1994) proposed that a necessary context was required for collective learning to occur. From their rich case study, four key attributes of this context emerged: Discipline, Stretch, Trust and Support. These authors indicated that all four attributes were essential for collective learning. Black & Boal (1997) examined this context in relation to group performance and the capability for change. Building on Black & Boal’s (1997) understanding of capacity to change, we focused on the context proposed by Ghoshal & Bartlett (1994) and refer to this context as the Context-for-Learning.

3. The influence bases

People may influence others face-to-face (directly) or through their influence on a group (indirectly). While many bases of influence exist (Pfeffer, 1992; Yukl & Chavez, 2002), we used two bases: position and personal power. Position power is typically structurally conferred and formally recognized. Thus, in organizations, the leader of a workgroup has position power by virtue of being in a formal organizational leadership role. However, individuals also have their own personal ability to influence others. Such personal influence bases may derive from friendship cliques, similarity comparisons, or perceived expertise. Since a person’s influence on specific areas of activity is often based on the amount of perceived expertise attributed to that person, we choose to use perceived expertise.

3.1. Indirect leader and follower influences

Indirect influence involves the influence of individuals on the group and back to all individuals involved. Black et al. (2005) modeled the indirect influences of leaders and followers through their effects on Group CFL. These researchers used leaders’ position power and followers’ expertise (personal power) as partial determinants of Group CFL. Group CFL, in turn, influenced individual leader’s and followers’ CFL. A followers’ similarity to the group moderated the degree of the influence of Group CFL on followers’ CFL. The model used in the current study included both direct and indirect influences on an individual and Group CFL.

3.2. Direct influences among leaders and followers

Direct influence usually reflects the influence of one individual upon another individual and/or upon himself or herself. Direct influence may also be thought of as the influence an individual has on his/her own behavior. Either type of direct influence may result in learning. While many types of learning exist (Gherardi, 1999; Huber, 1991), this study includes only two direct types of influences. We recognize that followers’ learning that occurs in the workplace involves embedded power relationships (Contu & Willmott, 2003). Therefore, the first type of direct influence is represented by leader-directed learning. The second type of direct influence is represented by the leader’s and the followers’ learning from themselves over time.

The first type of direct influence (the leader’s influence on a follower) assumed that the follower notices the leader’s behavior. Thus we expected that followers experience leader-directed learning (Agashae & Bratton, 2001; Neck & Manz, 1996) which occurs during leader–member exchanges (Mauer, Pierce, & Shore, 2002). Specific leader behaviors are specified in Quinn’s CVF and specific competencies are included in the CFL. This detail allows us to
examine the leader’s behavioral influence on CFL competencies. To determine the amount of influence of the leader’s behavior on the individual followers’ competencies, we created a theoretical influence matrix described in detail in Method.

The second type of direct influence (learning from oneself) (Jaber & Kher, 2002; Lawson, 2001) is represented by experiential learning. We defined experiential learning (Charalampous, Boyatzis, & Kolb, 2002; Kolb, 1984) as that learning which occurs by leaders and followers through their engagement in daily work practices. It was assumed that individuals will learn when given the opportunity through interaction and daily work.

4. Combined theoretical model and hypotheses

Thus far, we have described the theoretical set of agents (leader, follower, and group) and relationships among agents (influence) and across time (learning) that were modeled in the simulation. We now frame our discussion of the theoretical model used in the simulation around three figures examining the change or learning for each of the agents. 

Fig. 2 depicts part of the theoretical model upon which our simulation was based, showing followers in a group who learn in two ways: experientially and leader-directed.

Fig. 3 depicts another part of the theoretical model upon which our simulation was based, showing the leader of a group who only learns through experiential learning.

Fig. 4 depicts the social construction of the Group CFL Profile.

Each figure is described in detail in the following paragraphs.

4.1. Fig. 2: Determining the follower’s CFL profile in a time step

Three items shown in Fig. 2 contribute to a follower’s experiential learning factor for each of the competencies in the follower’s CFL Profile (Discipline, Stretch, Trust and Support). First, each follower has his or her own follower’s CFL Index with an associated learning factor (Box A). Second, each competence in the follower’s CFL Profile has an associated learning factor (Box B). Third, each follower’s experiential learning is influenced by the Group CFL Index and its associated learning factor (Box C). The development of the Group CFL Profile, Group CFL Index and its
associated learning factor is detailed later during the discussion of Fig. 4. These three items (Follower CFL Index, Follower CFL profile and Group CFL Index) and their associated learning factors were combined to create a follower’s experiential learning factor (Box D) for that CFL Profile competence.

Three items contribute to a follower’s leader-directed learning factor. First, each follower has an experiential learning factor (Box D). Second, each follower may or may not pay attention to the behavior of the leader (Box E). Third, each leader exhibits a leader’s behavior (Box F). These three items (Follower’s Experiential Learning Factor, Follower’s Attention and Leader’s Behavior) were combined into the leader-directed learning factor (Box H).

Three items contribute to a Follower’s CFL Profile (Box I). First, each follower has a CFL Profile (Box G), at the beginning of the current time step (Box I). Second, each follower has an experiential learning factor (Box D). Third, each follower has a leader-directed learning factor (Box H). These three items (Follower’s CFL Profile, Follower’s Experiential Learning Factor and Leader Directed-Learning Factor) were combined into a Follower’s CFL Profile (t_{i+1}), for the next time step (Box I).

4.2. Fig. 3: Determining the leader’s CFL and CVF profiles in a time step

Fig. 3 shows a leader has two types of experiential learning: CFL Experiential Learning Factor and CVF Experiential Learning Factor. Three items contribute to a leader’s CFL Experiential Learning Factor (Box E). First, each leader has his or her own personal CFL Profile competence and an associated learning factor (Box A). Second, each leader has a CFL Index with an associated learning factor (Box B). Finally, each leader’s experiential learning is influenced by the Group CFL Index and its associated learning factor (Box C). These three items and their associated learning factors (Leader CFL Index, Leader CFL profile and Group CFL Index) were combined using a weighted average to create a leader’s experiential learning factor (Box E).

Three items contribute to a leader’s CVF Experiential Learning Factor. First, each leader has his or her own personal CFL Index with an associated learning factor (Box B). Second, each leader’s experiential learning is influenced by the Group CFL Index and its associated learning factor (Box C). Finally, for each CVF profile component, each leader has an
associated learning factor (Box D). These three items and their associated learning factors (Leader CFL Index, Group CFL Index, and Leader CVF Profile) were combined to create a leader’s CVF Experiential Learning Factor (Box F).

Unlike the follower, the leader has no leader-directed learning. However, the leader has a learning factor derived from the tension among leader roles as described in Quinn’s CVF model. Taking the most restrictive stance, we assume that the leader will increase his or her expertise in leader behaviors in up to four of the eight leader roles of the CVF model in one time step. However, a change in leader expertise can only occur in one role of each competing pair of roles (See Fig. 1). Specifically, the leader will learn (Box G) in the role in which the leader has the highest expertise or, if the competing roles are roughly equal, the role in which learning occurs is chosen at random. The leader’s CVF Experiential Learning Factor (Box F) and the leader’s CVF Tension (Box G) were combined to generate the leader’s CVF Profile-Directed Learning Factor (Box J).

The leader’s CFL Profile ($t_i+1$) for the next time step (Box K) is the combination of the leader’s CFL Profile ($t_i$) at the beginning of the time step (Box H) and the leader’s CFL Experiential Learning Factor (Box E). The leader’s CVF Profile ($t_i+1$) for the next time step (Box L) was the combination of the leader’s CVF Profile ($t_i$) at the beginning of the current time step (Box I) and the leader’s CVF Profile-Directed Learning Factor (Box J).

4.3. Fig. 4: Determining the group Context-For-Learning (CFL) index learning factor in a time step

Fig. 4 shows the development of the Group’s CFL Index and an associated learning factor. The leader’s CFL Profile (Box A) and the followers’ CFL Profile (Box C) are combined to create the Group CFL Profile (Box E). The leader’s position power (Box B) and followers’ expertise power (Box D) are used to assign weights to the relative contributions of Box A and Box C. The Group CFL Index (Box F) is derived from the Group CFL Profile (Box E) by averaging the four CFL competencies. The Group CFL Index Learning Factor (Box G) was derived from the Group CFL Index using a standard $s$-learning curve.

To summarize, initial input for this simulation was at the individual level. The simulation then calculated emergent group level results and applied these results back onto the individual level and calculated new inputs for the next time step. By definition, in agent-based modeling the change occurs at the individual level and the group level responses emerge from those individual level changes (cf. Carley, 1995). This simulation explicitly includes both levels and their impacts on each other.
5. Hypotheses

The hypotheses for this article were based on predicting the output of a simulation (derived from the earlier theoretical discussion) and the variation of inputs. The inputs possible to vary were the leader and the set of followers. The leaders were chosen from the archetypical CVF profiles presented by Quinn et al. Here, we used homogenous groups of followers. Such groups of followers had similar CFL profiles. If the followers all had relatively high values in their CFL profiles they were considered a High Group. Alternatively, if they all had relatively low values they were considered a Low Group.

5.1. Leader/workgroup combinations differ

The output of the simulation which is used in the discussion below is the Group CFL Index (Fig. 4, Box F). We defined the developmental path to be this Group CFL Index plotted for each time step of the simulation. Because of the complex system nature of agent-based modeling, we expected that there would be differences in runs when the simulation was reset and rerun with the same beginning data; however, we expected that these differences would be smaller than when different inputs were involved. Here, we were interested in differences in developmental path due to the effects of the differing leader profiles. We expected, for a specific group, that the development path for any one leader profile with the same group to be more similar than the development path of a different leader profile with that same group. Thus, we hypothesize:

Hypothesis 1. The average across the developmental paths of multiple runs of the simulation for a specific leader–group combination would be different from the average developmental paths from other leader–group combinations.

5.2. Ineffective CVF leaders

From the competing values framework (Quinn et al., 2003), leader profiles of the Drowning Workaholic, Extreme Unproductive, the Abrasive Coordinator, and the Chaotic Adapter are ineffective leader profiles. Due to the low skill levels in the leader profiles, it was anticipated that the leaders would have a slow impact, if any, on the individuals and the resulting Group CFL Index. They might even pull down a group which was performing better than they were. Such paths would be graphed relatively parallel with the horizontal axis or possibly have a negative slope. Thus, we hypothesize:

Hypothesis 2. Ineffective Leader CVF profiles with any group would result in flat to negative simulated developmental paths of the Group’s CFL Index.

5.3. Effective CVF leaders

The CVF Profiles identified by Quinn et al. (2003) also identified effective leader profiles: Aggressive Achiever, Conceptual Producer, Peaceful Team Builder and Master Manager. Each of these leader profiles had skill levels in at least the marginally effective range. We expected that these leaders would show rapid growth in improvement of their leader behavior skills. Due to higher skill levels, we also anticipated that these leaders should be able to affect positive changes in the Group CFL at a much faster rate than the ineffective leaders. Such graphs were expected to deviate positively from the horizontal axis. Thus, we hypothesize:

Hypothesis 3. Effective Leader CVF Profiles with any group will result in positive sloped simulated developmental paths of the Group’s CFL Index.

5.4. Stability of master manager leader

Furthermore, Quinn’s work indicated that the Master Manager profile should outperform the other profiles. Thus, we predicted that the groups with a Master Manager leader would outperform those same groups with other leaders. We measured performance in two ways: the time step number for the Group CFL Index at the point of stabilization
(when it leveled out) and the value of the Group CFL Index at that time step. We expected that the Master Manager leader would bring the group to a point of stabilization faster than other leaders and that the level at which it stabilized would be a high level (e.g., 6 on a 7 point Likert scale). Thus, we hypothesize:

**Hypothesis 4a.** For an initial High Group, the simulated developmental paths of the Group’s CFL Index with a Master Manager leader would stabilize before the paths of the other leaders.

**Hypothesis 4b.** For an initial High Group, the simulated developmental paths of the Group’s CFL Index with a Master Manager leader would reach 6 before the paths of the other leaders.

**Hypothesis 4c.** For an initial Low Group, the simulated developmental paths of the Group’s CFL Index with a Master Manager leader would stabilize before the paths of the other leaders.

**Hypothesis 4d.** For an initial Low Group, the simulated developmental paths of the Group’s CFL Index with a Master Manager leader would reach 6 before the paths of the other leaders.

### 6. Method

#### 6.1. Integrated model and agent-based modeling

We expect the CFL Index for group members to change over time due to the interactions the group members have with each other. Therefore, agent-based modeling (ABM) was chosen for this analysis because it emphasizes realism rather than simplicity (Carley, 1995). ABMs were not expected to completely represent reality, but allowed us to explore theoretical variations and implications in a systems perspective. After examining theoretical implications, simulation results can be compared directly against data obtained from the real world (Jacobsen & House, 2001).

ABM attempts to explain collective or macro-level behavior based on individual or micro-level actions and interactions (Carley & Prietula, 1998). Agent-based modeling of complex adaptive systems requires the following: (1) identifying agent characteristics, (2) identifying the dimensions of relationships among the agents and (3) identifying the goals that govern their coevolution (Lewin, Parker, & Birute, 1998).

All the data inputs here are from synthetic data. This means that the data used were generated according to parameters and not gathered from respondents. The parameters thus describe the boundary conditions in much the same way that the information about a sample describes the boundary conditions for statistical inferences. This simulation used input data that mirrored questionnaires. Thus, the questionnaire data are not linked to any particular outside group of people but rather are generated to show specific parameters. When we discuss a leader or a follower, we are referring to virtual leaders and followers and not actual people.

#### 6.2. Identifying agent characteristics

There are three agents in our model: a leader, followers, and a group. Each group consists of exactly eight members: seven followers and one leader. A follower is represented by his or her expertise level and CFL Profile. A leader is represented by his or her position power, a CFL Profile, and a CVF Profile.

Groups were created by selecting a leader representation from one of the eight CVF archetypical leader profiles and a set of seven followers. Homogenous groups of followers were created by assigning all high (or all low) profile values to the members of a specific group. These groups correspond to the High or Low Groups in the hypotheses.

#### 6.3. Identifying relationships and goals for the simulation

There are seven relationships across time which influence the follower, leader and group learning in the competencies associated with the CFL and CVF Profiles: (1) Follower ($T_i$)-to-Follower ($T_{i+1}$), (2) Group ($T_i$)-to-Follower ($T_{i+1}$), (3) Leader ($T_i$)-to-Follower ($T_{i+1}$), (4) Group ($T_i$)-to-Leader ($T_{i+1}$), (5) Leader ($T_i$)-to-Leader ($T_{i+1}$), (6) Leader ($T_i$)-to-Group ($T_{i+1}$), and (7) Follower ($T_i$)-to-Group ($T_{i+1}$). The Follower-to-Follower, Group-to-Follower, Leader-to-Follower relationships across time are detailed in Fig. 2. The Leader-to-Leader and Group-to-Leader relationships are detailed in Fig. 3. The Leader-to-Group and Follower-to-Group relationships are detailed in Fig. 4.
The goal identified for the coevolution processing in this simulation is to maximize the growth of the Group CFL Index (Fig. 4, Box F) and, by implication, group performance (Black & Boal, 1997). This growth is shown in the developmental path described earlier.

6.4. Input data for agents

6.4.1. Input data for the leader

Each of the eight archetypal leaders is represented in the simulation by a level of position power, CVF Profile and CFL Profile. The leader’s position power indicates which group member is designated as the leader. The CVF Profiles for each archetypal leader were extrapolated from the graphs published by Quinn et al. (2003) in his textbook. A contribution of this article is the linking of the CFL values with CVF Profiles. To determine the CFL value to use with a specific CVF Profile, the CVF and CFL questionnaires from 71 leaders from service and manufacturing organizations were examined. Their positions ranged from frontline supervision up to top level management. The manager with the CVF Profile values that most closely matched each of the eight Quinn archetypal leaders was identified. These eight leaders’ associated CFL Profiles were used as the initial CFL Profiles of the eight archetypal leader types.

6.4.2. Input data for a follower

A follower was represented in the simulation by expertise level and a CFL Profile. The CFL Profile for the followers in a Low Group was initialized with uniformly random numbers between 1 and 3. The CFL Profile for the followers in a High Group was initialized with uniformly random numbers between 5 and 7. All of the followers in a group were initially given the same synthetic data for position power component (0 for followers). The expertise level was synthetically generated.

6.4.3. Input data for group

The input data for the group emerged from the data associated with seven followers and one leader. Rather than using a simple average across group members to calculate a group representation, influence bases were explicitly recognized. The influence relationships involved were operationalized using position and expertise power to calculate a weighted score for the Group CFL Index. Followers influence the group only through position power. The leader contributes 50% to the Group CFL Index. The followers contribute the remaining 50% based on their relative expertise.

6.5. Input data for relationships

6.5.1. Follower-to-follower relationship: follower’s experiential learning

As discussed earlier, followers learn from experiential learning and leader-directed learning. The simulation assumed that changes in followers would be reflected in their CFL Profiles and expertise. At each time step of the simulation, their CFL Profiles and expertise were updated using the associated learning factor.

6.5.2. Group-to-follower relationship: group’s influence within a time step

Here, freedom of movement in and out of a group in the simulation was restrained to 0. Because of the size of the workgroup in this simulation (7 members plus the leader), each group member was assumed to be aware of each other group member and thus the group would always impact the individual. The rules that affect the group’s influence back onto the individual are based in the social structuration literature (Giddens, 1977). CFL Profiles of individual followers were compared to their group’s CFL Profile to determine if these profiles were similar. If they were similar, the group contributed 50% of the influence on the follower’s experiential learning factor in a single time step (Fig. 2, Box D). The follower contributed the other 50% of the influence in this situation. If the follower and group’s CFL Profile were dissimilar, then the group contributed only 25% of the influence and the follower contributed 75% of the influence on the follower’s experiential learning factor.

6.5.3. Leader-to-follower relationship: leader-directed learning

We were confident that these leader behaviors would all impact the Context-for-Learning given the recent research by Vera & Crossan (2004). To determine the amount of potential influence from the leader behaviors on the follower’s
perceptions of the CFL, we followed the practice of using a panel of leadership experts to evaluate questionnaire items and constructs (Baron & Ward, 2004; Langfred, 2004). We used a panel of nine leadership researchers selected from academics who had authored leadership articles and/or who were responsible for teaching leadership courses at institutions of higher education.

The panelists were given a matrix where the columns were the behaviors associated with the eight leader roles identified by Quinn and the rows were the specific embedded competencies from the CFL Profile. The panelists were asked to enter a 1 if they believed that the leader role behavior would influence an individual’s perception of each CFL Profile embedded competence. The relationships among the four attributes and the eight leader roles were derived from the experts’ responses. Because the panelists were asked to link together two theoretical models that had not been linked together before, all information was used rather than just those cells that showed the largest agreement. A theoretical influence matrix (see Table 1) was generated as the weighted percent of agreement across experts on the influence of a leader’s behavior on the CFL Profile competencies of followers.

The weighted percent of agreement values in the theoretical influence matrix were used as a proxy for the maximum amount of time a leader’s behavior impacted a follower’s perception. Operationally, this table displays the maximum percent of the time that the leader’s behavior will influence the followers. The table indicates that a leader’s Innovator behaviors will impact a follower’s perception of Discipline 5% of the time while a leader’s Mentor behaviors will impact the Discipline competence level 39% of the time. The leader’s influence was calculated for each time step for each follower’s CFL Profile competence by generating a random number between 0 and 1 for the follower’s noticing of the leader behavior. If this number was less than or equal to the value given in the theoretical influence matrix, then the leader role behaviors influenced the follower’s CFL Profile element. Otherwise, there was no leader-directed learning for that CFL Profile element during that time step.

6.5.4. Leader-to-leader relationship: leader’s experiential and directed learning

The leader learns experientially in the same fashion for his or her CFL Profile and CVF Profile as was represented for the follower. While Quinn argued that leaders may learn in both competing CVF Profile roles at any given time, our model constrained learning to only one in a given time step. Further, the model assumed that a leader will learn in the role in which he or she is strongest. However, if neither role dominated, then a stochastic process was used to select the role in which learning occurs. Leaders do not experience leader-directed learning because they do not have leaders in this simulation.

6.6. Running the simulation

One of the reasons for running a simulation was to begin to understand systemic effects of actions (Sterman, 2000). Each run of the simulation was the equivalent of a virtual experiment. A single run of a number of time steps was adequate for a computational model or simulation that had everything pre-specified. However, because this simulation had two parts containing stochastic elements, multiple iterations running the series of time steps were necessary. Thus, a run was defined as 1000 repetitions of 80 time steps. A run was done for each specific leader–group combination. The output from each run was examined and, after confirming that the variance of the developmental paths for each leader was effectively 0 (they ranged from 0.00005 to 0.0001), summary graphs were used for hypotheses testing.

7. Results of the simulation

It is interesting to note that for all leader–group combinations, the developmental paths reached the highest CFL Index value of 7. This finding was determined to be an inherent characteristic of the simulation since it currently
modeled learning as a generally increasing effect. This is because knowledge or expertise was modeled so that once learned or acquired it is never forgotten or never fades. A group member’s knowledge can decrease only if the group’s knowledge is lower than the group member’s and close enough to the group member for him or her to accept that influence. Since people do forget and lose expertise, this assumption is restrictive and bears examination in future virtual experiments.

7.1. Hypothesis 1

Our first hypothesis was that running the simulation with different leader archetype profiles would result in different simulated developmental paths of the CFL Index. Each of the eight archetype leader profiles was combined with synthetic data representing a High Group. The summary graph revealing the average developmental path for the eight Leader–High Group combinations is shown in Fig. 5.

There are visual differences among the developmental paths of the CFL Index. However, beginning at about 10 time steps and finishing at about 35 time steps, all developmental paths flatten and converge at the highest level of competence, 7. Visual discrimination was sufficient to determine that all leaders had separate and distinct paths until the maximum value of 7 is attained. This conclusion was verified by determining the equations for each of the developmental paths which were found to be unique.

The rest of the test for Hypothesis 1 examined the leaders combined with synthetic data representing Low Groups. Each of the eight archetype leader profiles was combined with synthetic data representing a Low Group. The summary graph revealed the average developmental paths for the eight Leader–Low Group combinations as shown in Fig. 6.

Again a visual examination of the average path of a leader in a Low Group reveals initial variations and a convergence to a competence level of 7. It is interesting to note that all the paths converge to the 7 beginning at about 35 time steps and ending at the 80th time step which lagged behind the High Groups. Again the developmental path for each leader had a distinct and separate path. The final comparison was to determine if any of the High or Low Group combinations duplicated paths. Each leader–group had a distinct path when all paths were graphed on a combined graph (see Fig. 7) and when compared to the equations of the other paths.
Interestingly though, the Extreme Unproductive–High Group and Drowning Workaholic–High Group combinations have developmental paths that are initially embedded among many of the Effective Leader–Low Group paths. It is not until 20 time steps that the Ineffective Leader–High Group combinations separate to form a continuum of paths. However, given the distinct summary graph for each leader–group combination, we conclude that there is support for Hypothesis 1.

7.2. Hypothesis 2

The next hypothesis dealt with the shape of the graphs for the ineffective leader profiles. We expected that the ineffective leader profiles would have relatively flat developmental paths. When we compared the developmental paths of all ineffective leader profiles (see Fig. 8), we saw that there was variation among the developmental paths across time steps. The High Groups all reached higher values of the context for learning faster than the Low Groups. The order in which these leader profiles enabled their groups to attain the highest level remained the same despite the group; this order was Chaotic Adaptive, Abrasive Coordinator, Drowning Workaholic and Extreme Unproductive. This order indicated a slight flattening in the graphs from the steepest, Chaotic Adaptive–High Group path, to the flattest, the Extreme Unproductive–Low Group path. The flatter graphs were the Drowning Workaholic–Low Group path and the Extreme Unproductive–Low Group path. There were distinct similarities among the High Group paths and separate distinct similarities among the Low Group paths.

Furthermore, when we compared these developmental paths with those of the Effective Leaders (see Fig. 9), we could see that both the group and the leader’s profile were necessary to determine the path’s progression. Thus both the relative ability of the leader and the relative ability of the group contributed to the determination of the flattening of the graph. No graphs had negative growth patterns. Hypothesis 2 was not supported.
7.3. Hypothesis 3

Hypothesis 3 followed the logic of Hypothesis 2 but with the Effective Leader profiles (see Fig. 9). An initial examination of the developmental paths of the Effective Leaders indicated that there was less variation within a High Group or Low Group pattern with the High Groups again having a different grouping than the Low Groups. Hypothesis 3 called for growth in the developmental paths of groups with Effective Leaders. All groups did grow. The order of effective leaders with High Groups reaching 7 was the same. All Effective Leaders with High Groups did reach 7 before the Ineffective Leaders with High Groups (see Fig. 5). All Effective Leaders with Low Groups did reach 7 before the Ineffective Leaders with Low Groups (see Fig. 6). Thus Hypothesis 3 was supported.

7.4. Hypotheses 4a, 4b, 4c, and 4d

These hypotheses stated that the Master Manager would have more of an impact on either a High or a Low Group than the other leader profiles. The twin goals of stabilizing fast and doing so at a high level of the developmental path were examined. In Hypotheses 4a and 4b, the Master Manager–High Group developmental path was predicted to reach a stabilized high level of the developmental path before the rest of the groups. We revisited Fig. 5 to determine the timing of the stabilization for the various leader profiles and the High Groups. The first to begin to stabilize was the Master Manager at about 12 time steps. It was followed by all the effective profiles and then the ineffective profiles. Given the separate paths (each path represents a different graph derived from the 1000 virtual experiments) and the different points for stabilization, we found support for Hypothesis 4a.

An initial “high” level of the Context-for-Learning was set at above 5. For the present, the ending “high” level was set to be at 6. As expected from our earlier discussion on the assumptions in the model regarding learning, all Leader–High Group combinations reached 7. However, the hypothesis indicated that the Master Manager’s group would reach 6 first. This was supported in the graphs but the other High Leader–High Group combinations rapidly followed. Thus, we concluded that Hypothesis 4b received support.

Hypotheses 4c and 4d examined the Master Manager–Low Group combination against the rest of the Leader–Low Group combinations. To examine this set of hypotheses we examined the stabilization patterns found in the developmental paths shown in Fig. 6. The Low Groups’ developmental paths had two inflection points where the slopes flatten. In both instances the Master Manager–Low Group combination reached those points first (about 11 time steps and 30 time steps). In the Low Group patterns this double inflection point was maintained; however, there was no convergence until 7 was attained. Stabilization did not occur until the maximum value of 7 was reached and this ranged from about 40 time steps to over 80 time steps. Because the Master Manager was consistently reaching these inflection points before the rest of the leader’s developmental paths, Hypothesis 4c was supported.

Hypothesis 4d called for the Master Manager–Low Group combination to reach a high level before any of the other Leader–Low Group combinations. Recall that a high level of competence in developmental path values was set at 6. In examining Fig. 6, again all leaders actually reached 7; however, the Master Manager’s developmental path definitely reached 6 first, thus, Hypothesis 4d was supported.

In summary, the simulation experiment provided support for 1, 3 and 4a, 4b, 4c, and 4d and no support for Hypothesis 2. Taken together, these experiments indicated that it was the leader–group combination which facilitated the most rapid attainment and stabilization of a developmental path. The rates of change in the developmental path
were obviously influenced by both the leader profile and the composition of the group. While all leader–group combinations reached the top level of 7, those groups which began with a relatively high developmental path had consistent and relatively rapid movement towards this high level and reached it by between 15 and 25 time steps. The Low Groups did not have that same consistent and relatively rapid movement. These groups had increasingly rapid growth until they reached an inflection point at about a level of 5.5. It took the Low Groups between 10 and 45 time steps to reach 5.5. After this level, their growth slowed down and they did not reach the second inflection point until they had basically reached 7 after 40 time steps.

8. Discussion

The difficulty in doing research on strategic resources that are the result of social interactions has long been noted whenever the “holistic” nature of such resources has been discussed. The use of simulations to test the set of components and the logic of specific relationships of a causally ambiguous social resource has great potential. This article confirmed that specifics about the people involved influence the creation of a Context-for-Learning in a group. It demonstrates that even the best leader may have difficulty efficiently creating such resources if the correct set of people is not involved. The use of simulations may even facilitate research on the deployment of people and may result in the more effective or efficient development of strategic resources.

We found support for our first hypothesis that each combination of leader and sets of followers had a distinct developmental path. In making this determination, two interesting side issues arose. The first one was that Low Groups lag High Groups by a considerable amount (the most effective path of the Low Group ends up about the same as the least effective path of the High Group). In addition we could see from Fig. 7 that the most effective leader, the Master Manager, with a Low Group performed about the same as the most ineffective leaders (the Drowning Workaholic and the Extreme Unproductive) with a High Group. This is an interesting system finding. It may be very difficult to disentangle the contributions of the leader and the group in such situations.

Our second hypothesis was not supported. The ineffective leaders did not create flat or negative developmental paths in this simulation. They did have a wider variation in the developmental paths than did the effective leaders but none actually drove the CFL downwards. This may have been due to our assumption that learning always occurs and is always positive. This is an area that needs further examination. One thing that we can say for sure is that the performance associated with an ineffective leader is highly dependent upon the group that the leader heads.

Our third hypothesis was supported. Effective leaders do enhance the performance of all groups. It was interesting to note that the variation among the developmental paths for effective leaders were much narrower than the variation among the developmental paths of ineffective leaders. Thus, a firm can have tighter expectations around what an effective leader might accomplish versus what an ineffective leader might accomplish.

It is also interesting to speculate that if the firm rewarded leaders based on leadership skills, there would be a wider range of possible outcomes than if the firm rewarded leaders based on group skills (compare Fig. 9 with Fig. 5). Indeed, a low level group with an effective leader (Master Manager) may outperform a High Group with an ineffective leader (Extreme Unproductive). Using only leader skills or only group attainment may hide problem areas that should be addressed.

Our fourth set of hypotheses was supported. The Master Manager was able to consistently outperform the other less balanced profiles. However, it is important also to note that the overall performance of the Master Manager was dependent upon the group.

8.1. Implications for leadership research

Simulations of complex adaptive systems can help researchers, practitioners and others interested in how such systems evolve to better understand some potential evolutionary patterns. The development of socially constructed strategic resources is one such complex adaptive system. This simulation demonstrated that leader behavior initially has an impact on a work group. Each path generated in this simulation was unique to individual leaders. The simulation also illustrated that the interaction between the leader and the group is important in understanding leadership effects.
Most leadership research has focused on leader characteristics, behaviors and situational factors (Fiedler & Garcia, 1987; Yukl, 2003) and how they affect individual followers. One major area of theory and research that focuses on the interaction of leaders and individual followers is Leader–Member Exchange Theory (Graen & Scandura, 1986). Our simulation recognized and explored the effects of leaders on individual followers and groups. It also addressed the development of the emergent Group Context-for-Learning and acknowledged that followers as well as leaders affect this group level resource over time. The dynamic interaction between leaders, individual followers, and groups has been missing in most leadership research. By representing this dynamic interaction as a complex system, this simulation allows researchers to obtain a more realistic picture of the effects of specific leader–member exchanges over time.

While acknowledging that none of our agents forget what they have learned, the relative placement of the paths followed Quinn's initial categorization of leader profiles as being effective or ineffective. However, the leader–group interaction effect and the convergence of paths mentioned in the results for Hypothesis 1 also helped explain some of the inconsistent results found, since an ineffective leader with a High Group could at certain points in time be outperforming an effective leader with a Low Group. Taking into account both the leader and the group appear to be important for both leadership and group research programs.

Individual follower and group learning factors included in this simulation may be viewed as substitutes or enhancers for leadership. Substitutes and enhancers are characteristics of followers, groups, tasks, or organizations that can moderate a leader’s effects and have important effects of their own on followers’ attitudes and/or performance (Howell, Dorfman, & Kerr, 1986). Followers’ experience, ability and knowledge have been described and researched as leadership substitutes and enhancers (Howell, Bowen, Dorfman, Kerr, & Podsakoff, 1990; Kerr & Jermier, 1978). This simulation provided initial evidence that similar characteristics may also affect follower and group learning. Since this learning is an important strategic organizational resource, the initial results of the simulation indicated that substitutes and enhancers may have a wider impact than researchers have recognized.

8.2. Implications for leadership practice

Although it is premature to make recommendations to practicing leaders based on this initial simulation, if these results are supported in future studies they may be important for leaders. Recognizing that specific leadership styles can expedite group learning can be critical for start ups, new projects and new hires. The Master Manager style may bring a group “up to speed” much more quickly than other styles and this is true regardless of the group’s beginning resources. There may also be specific leader styles that are relatively ineffective in promoting group learning. The Extreme Unproductive style appears to be one example. This type of knowledge can be most helpful for training and development. This simulation showed that initial composition of a group also importantly affects the rate of group learning. Leaders may be able to selectively assign individuals to task groups to increase the rate of group learning on a particularly important project. This strategy, combined with a leader whose style approximates the Master Manager, may produce optimal results.

8.3. Limitations

This computational model had some restrictive assumptions which might have impacted its usefulness. These assumptions, while a reasonable starting point, require further examination. One of these assumptions was that all individuals, when presented with the opportunity to learn, will learn and that there will be no forgetting or resistance to learning beyond that included (due to similarity of the individual to the group and power relationships). We also assumed that the leader would only learn in four of the eight roles. This is a restrictive assumption and it would be important to relax that assumption along with the always learning assumption and to determine the impact of these assumptions on the developmental paths. Another assumption is that all learning occurs along the same “s” curve with individuals simply placed at differing points along that curve. This assumption again provides a starting point but needs examination in future work.

This project has used synthetic data for inputs to the simulation. These synthetic data, while based on questionnaires to which real people can respond, did not reflect actual environments. While such virtual “thought” experiments are useful, it is also important to verify the veracity of the simulation in the field. As researchers, we need to be careful to not overstate the applicability of the implications. This point again provides opportunity for future work.
The theoretical influence matrix is an initial attempt at linking together the CFL and CVF questionnaires. There is therefore reasonable concern that this linkage not be assumed to be the final word on the relationship between these two questionnaires but rather the starting point. Thus, if future work determines that our panel of experts was wrong, then the results of the simulation will be called into doubt.

8.4. Future research

Some future research opportunities were mentioned as we dealt with the limitations of the model. Additional research opportunities are also present. We presented a simulation model derived from theory that only included one leader and seven of his or her followers. Thus, while we expect that the model will illuminate real world activities, it is not a predictive model. A next step in this research stream is to take the simulation out of the ivory tower and down to the work floor. Such an effort would entail obtaining the input from real workgroups over time and comparing the changes in their responses to changes in the responses as predicted by the simulation. Alternatively, showing the developmental paths of theoretical groups and their leaders to real workgroups and determining if they can describe scenarios for the paths that match our theoretical descriptions may also help with the validity of our model. Because of the stochastic and agent-based nature of this model, point-for-point predictions will not be possible; however, we do hope to understand the “pattern” of development so that pattern classifications can occur even when point predictions cannot.

Another future research stream is in modeling the development of a leader into a Master Manager. Certainly, having an adequate skill level in each of the eight behaviors is a necessary condition to effectively use the skills. However, beyond just having the skill set is the ability to know when to use the skills. The sequencing and pace of use of behaviors and its impact on workgroups is another area where virtual experiments such as this simulation can help us understand organizational practices and processes.

This simulation could be extended to be useful to Leader–Member Exchange researchers by exploring the impacts of in-group versus out-group exchanges on follower and group learning. The attention paid to the theoretical influence matrix might be adjusted to reflect in-group members or subgroups (weight influence factors higher) and out-group members or subgroups (weight influence factors lower) and how these differences affect group development. Power differences could also be studied with this simulation by varying the distributions of position based and expert power of the leaders. Both of these power sources are critical to creating and maintaining a leader’s influence and have played major roles in popular leadership models and in research (Fiedler, 1978; Yukl, 2003).

To our knowledge, little or no leadership research has addressed the effects of experiential learning by the leader over time and the impact of the workgroup on that experiential learning. Our assumption in this simulation about followers continuing to learn applies equally to leaders. We assume that leaders also learn with regard to their leadership skills. The leaders in our simulation had the opportunity to learn via experience in four of the eight leader roles. Future research can examine the actual learning in each role and the additional impact of directed training. By including these issues, a more realistic assessment can be obtained of a leader’s impact over time.

Further work on this simulation may provide answers to the following questions: (1) What happens if one has a fairly effective group and one switches leaders? (2) What effect does a series of leaders have on a group in addition to the issues included here? (3) Will a series of leaders erode the trust that a group has for a leader? (4) What happens in self-directed work teams, when the team members are expected to have “leader roles”? (5) What are the changes in the Context-for-Learning embedded competencies of discipline, stretch, trust and support that were collapsed in this early effort?

We are interested in developing the model from the one workgroup organization into a multi-workgroup organization or even a multi-organization network. We are also interested in field testing the model with micro-businesses and then with network organizations such as those that respond to governmental calls for proposals. We look forward to exploring this model in greater detail with real organizations across such a variety of scenarios.

References


