IMPLICATIONS OF ACTION THEORIES TO LEAN CONSTRUCTION APPLICATIONS

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ABSTRACT

Two models of Action Theory offer fundamentally different views of the merits and appropriate use of plans. While the Deliberative Action model considers plans as a necessary prerequisite for project execution, the Situated Action model offers an alternative view in which plans are intrinsically imperfect due to the limited information visible to any planning agent. This paper discusses these competing models, emphasizing their implications to Lean Construction and the construction project planning and execution process in general. Two current planning and execution paradigms are used to illustrate these issues, namely the Critical Path Method and the Last Planner System. The former is a prototypical Deliberative model technique, while the latter exemplifies a Lean Construction application with many Situated Action model features. This paper ends with a conclusion section discussing the implications of both models and recommendations for further research.

KEY WORDS

Lean Construction, Planning, Action Theory.

Democritus said, words are but the shadows of actions.
Plutarch (A.D. 46?-A.D. c. 120): Of the Training of Children.

INTRODUCTION

The lack of a theoretical basis for construction project management has been pointed out and lamented in the literature (e.g., Koskela and Howell, 2002, Koskela, 2000, Halpin, 1993). The absence of a reference framework for the explicit and implicit rationale underlying project management decisions has resulted in mostly Byzantine discussions about the merits and drawbacks of current construction project management methods, since there is no consistency in what attributes to look for to assess them.

This paper analyzes the reasoning behind many management actions (i.e., their theoretical underpinning) using the perspective of Action Theory. The traditional action rationale (the *Deliberative* Action model) has been challenged by an alternative model (the *Situated* Action model), which posits that there are fundamental flaws in traditional assumptions about the nature of action. The ongoing debate on the merits and limitations of these competing action models closely follows the discussion taking place in the construction management arena about the merits of traditional project management approaches, epitomized by the Critical Path Method, and alternative management environment and methods, especially in Lean Construction, exemplified by the Last Planner System.

This article's body begins with an introduction to Action Theory and its two competing models, followed by a discussion of the general context of construction

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management practice from an Action Theory viewpoint. The Critical Path Method and the Last Planner System are briefly described, followed by a discussion of their features, again emphasizing issues relative to Action Theory. Three important issues separating these two methods are discussed in further detail, namely their approach to the nature of the world, the updating of their plans, and the role of instructions in each system. This paper ends offering thoughts about the implications and possible next steps derived from the issues discussed here.

ACTION THEORY

BACKGROUND

Action Theory is concerned with the behaviour of an individual agent as a result of its interaction with a situation. It is particularly interested in the nature of action: the distinction "between the things that merely *happen* to people -- the events they undergo -- and the various things they genuinely *do*" (Action, 2002). Action Theory is of interest to a wide and increasing number of fields, such as artificial intelligence, linguistics and human-machine interfaces.

The role of Action Theory to solve a seemingly intractable problem in robotics illustrates its extensive applications (Agre, 1997). In the 1970s, robot programmers found that despite their best efforts, no controlling software was complete enough to include a proper reaction to all situations encountered by a robot moving in a room with normal obstacles and imperfections. The two approaches initially considered to solve the problem were to increase the number of scenarios modelled at the expense of increasing complexity and reaction time, or reducing the reaction time at the expense of not considering all scenarios. Action Theory, and more specifically the Situated Action model discussed later here, provided the rationale for what is now the standard solution to this problem: make the sensing and acting as local as possible, concentrating on immediate data. A relatively small central program detects the overall shape and solution of a problem ("turn right to avoid the table ahead"), but it does not describe the details of how to turn right to the wheeling actuators. Many construction practitioners will recognize similarities between this case and the challenges typically encountered in managing a project: no matter how detailed a project plan is, there will be unaccounted situations requiring a quick response. Action Theory models address this dilemma of thoroughness and central control versus versatility and fast turnaround.

THE DELIBERATIVE ACTION MODEL

The Deliberative Action model asserts that project execution should be dictated by a comprehensive plan resulting from a deliberate intellectual effort to develop and use a symbolic model of the project (Johnston, 2000). A main goal of actors implementing this plan is to avoid divergences from the prescribed course of action, and to feed information to the symbolic model so that it can forecast deviations or change the original project plan.

In the Deliberative Action model, a central agent collects all possible information about the project and constructs a symbolic model of the world in which the project will be performed. Then, the model simulates an acceptable sequence of actions to achieve the desired goal, and the optimum output on the model is translated into actionable instructions. The output from this virtual model is The Plan, which serves as the command mechanism for the execution of all actions (Johnston and Brennan, 1996).

Actors implementing The Plan have a subordinate role, if any, in deciding the steps to reach the desired goal. Successfully executing an action is synonymous with successfully following its Plan. Control consists primarily of measuring regularly project performance using metrics that can identify variances from The Plan. This information is passed to the central agent, who translates it into input suitable to the symbolic action model. The model simulates future state of the world, and the agent may decide – normally as a last resort – to change The Plan if the divergence between the world and The Plan is too large to get back to the originally intended track.

It is common to find formal plans "decorating the project management office walls on site" (Docherty, 1972). In most construction projects, particularly, "[e]xecution proper is governed by informal short-term planning performed by site/work field personnel, at times totally disavowing the formal plans" (Docherty, 1972). This dichotomy between the intended, centralized execution envisioned by The Plan and its seemingly inexplicable rejection by the actors in charge of its execution has mystified proponents of the Deliberative Action model: Regardless of any attention to detail, the updating of plans developed around this model cannot keep up with the execution pace of most projects.

THE SITUATED ACTION MODEL

The Situated Action model has come to the fore of Action Theory in the last decades, challenging many of the premises of the Deliberative Action model. The fundamental insight of the Situated Action model is that everyone is immersed in an environment. This fact limits an agent's ability to perceive reality and to plan any action. In contrast, the deliberative action model implicitly assumes that an agent can see the world from a detached position, "some 'aerial' viewpoint away from the action" (Agre, 1995). In other words, the deliberative model assumes that the agent sees all the pieces of the action. This is never the case. An agent is always *situated* in the world, hence the name of the Situated Action model.

Situatedness has been frequently explained using game-playing metaphors (e.g., Chapman, 1991). The classic video arcade game of Pac-Man offers a good metaphor to explain this concept. The objective of the game is to circulate its hero – Pac-Man – through all the branches of a maze laid out in the screen so that it eats all the "pac-dots" spread on the branches, and the challenge is avoiding the moving evil ghosts trying to catch Pac-Man. It would be extraordinarily difficult to win at the game if it were played from Pac-Man's perspective, that is, if the player were able to see only the walls of the maze. The game is easier because the player can see the Pac-Man, the maze and the evil ghosts from above. Similarly, planning and executing an action would be much easier if all eventualities could be observed from a vantage point. However, a planner can see only a small portion of the world, because she is immersed, or *situated*, in it.

Another fundamental insight offered by the Situated Action model is that any action performed by an agent affects her environment, and any change in the environment affects the actions taken by the agent. This reciprocity has been described as "a dance between ourselves as relatively autonomous agents and an environment of rich structure" (Johnston, 2000). As Agree (1997) rightly points out, "action is not realized fantasy but engagement with reality."

A situated action principle with great practical implications is that the vast majority of actions taken by an agent follow a stable routine; no one could function if each step in everyday life would need to be planned and evaluated. It follows that the more *routinised* an environment can be, the more time actors can devote to the performance of actions meaningful to the pursuit of their goal (Johnston et al., 2005, using U.K. grammar *routinised*). A structured environment relieves much of the cognitive burden that would be required to navigate an unstructured environment.

As a corollary of the previous principle, planning an action should be an exceptional event, only becoming necessary when there is a break down of an agent's routine. The term *break down* is taken in the very general sense discussed by Heidegger (Heidegger, 1962) when he points out that routine artefacts, cultural or physical, are "invisible" to their user until a disturbance makes them "visible."

Lastly, the Situated Action model posits that actions should be informed, but not dictated, by the project plan. Agre and Chapman (1990) call this distinction "plans-as-programs" in the Deliberative Action model, and "plans as-communications" in the Situated Action model.

The Situated Action model has been called a "congeries of theoretical views" by unforgiving authors (Vera and Simon, 1993). The Situated Action model has evolved over time, and it has no canon defining what is or is not *situated*. Consequently, there is no "perfectly situated" project management system, although there have been attempts to formalize one (e.g., Johnson et al., 2005).

CONSTRUCTION MANAGEMENT AND ACTION THEORY

Construction project management overwhelmingly follows the underlying thinking and methods of the Deliberative Action model, even if its assumptions and prescriptions are implicit – invisible – to most construction practitioners. Examples of deliberative thinking saturate the Project Management Book of Knowledge, or PMBOK, which is a collection of normally accepted practices collected by the Project Management Institute (PMI, 2004). The PMBOK clearly establishes the plan-then-act premise of the deliberative model (Koskela and Howell, 2002). Section 4.4 states that "Project plan execution is the primary process for carrying on the project plan." Change is anathema to deliberative thinking, and the PMBOK follows this reasoning by stating in Section 4.6 that "many control systems include a change control board (CCB) responsible for approving or rejecting change requests."

An increasingly popular alternative to traditional project management, especially in aspects concerning the construction industry, is offered by the relatively new (and relatively loose) set of management practices known as Lean Construction. It originated as a response to the low and stagnant productivity typical in the execution of construction projects, especially when compared to the remarkable improvements achieved in the manufacturing industry. The Lean Construction movement began in earnest in the 1990s inspired by the Lean Production method created by Toyota Motors (Ohno, 1988) and a scholar's manifesto (Koskela, 1992). Despite the many commonalities between these two lean movements, Lean Construction has developed its own set of practices, one of which is discussed here.

Lean Construction has many principles intrinsically close to the Situated Action model. The essence of many of its tenets could be summarized as the constant checking of reality and the deliberate rejection of the illusory. Early Lean Construction literature did not discuss Action Theory explicitly, but given their commonalities, more recent articles address this theory (e.g., Koskela, 2000).

CRITICAL PATH METHOD AND LAST PLANNER SYSTEM

Contrasting two construction project management systems can elucidate by example many of the differences between action models, and help in discussing the implications of Action Theory to construction project management.

The Critical Path Method (CPM) is the quintessential example of a system based on the deliberative model, while the Last Planner System (LPS) applies many situated action principles rooted on Lean Production methods. Although some authors attempt to conciliate LPS and CPM (e.g., Huber and Reiser, 2003), many LPS practitioners are doubtful, at best, of the merits of CPM (e.g., Macomber, 2002), and vice versa, in this author's experience, CPM practitioners tend to see LPS as an impractical tool.

The Critical Path Method (CPM) has been available since the late 1950s and is a standard topic in any construction management curriculum (Korman, 2004, Macomber, 2002). CPM practice generally includes the creation of an encompassing project execution plan, from preconstruction to closeout, using a Work Breakdown Structure to generate an activity list and the input of selected construction experts to create an activity network. The output of its computation algorithm includes the earliest date by which each activity can be started, and the allowable time leeway for the start of each activity before its delay affects the finish date of the overall project. Ancillary computations include the creation of profiles of resource requirements through the project execution, and rescheduling of activities to avoid conflicts in resource usage.

CPM plans have experienced consistent problems with their implementation. Since its early days, these problems have been attributed to reasons external to the method, such as misconceptions about the technique or a lack of proper education (Robinson, 1965). It is remarkable that, many years later, reasons for failure and solutions advocated by many CPM proponents have remained constant (e.g., Korman, 2004). A minority, such as Birrell (1980) has voiced concerns with the method, e.g., "Failure of the majority [of practitioners]…to use CPM or PERT…exposes that there is some fundamental failure in the CPM/PERT technique" (Birrell, 1980).

In contrast with CPM, the Last Planner System (LPS) is more recent, having been formally introduced in the 1990s (Ballard, 1994, Ballard, 2000, Ballard and Howell, 2003). While it is well known to construction managers implementing Lean Construction, it is not a widespread academic topic, nor is it use usually compelled by contractual requirements. LPS involves several levels of planning, proceeding from a broader to a specific level of detail, and with responsibilities in creating and implementing the execution plan that go in parallel with the duties of the various management levels in a construction project. The system's name recognizes the key role of foremen and other field personnel in the day-to-day decisions affecting project execution: they are the last planners, both chronologically and in responsibility, before the physical construction of any project component. LPS emphasizes the value of reliable plans, and prescribes a set of practices much "softer" than those of CPM. Whereas CPM has a well-defined mathematical algorithm with an end result of essentially numerical data, LPS consists of management recommendations and simple metrics, allowing much flexibility in its implementation.

LPS attempts to situate each planning decision as close as possible to the individual in the best position to understand it. Setting major project execution milestones is a responsibility of top management; middle management (such as superintendents) must enable field crews to perform their tasks by readying all the designs, permits and other resources in time for their use by field personnel. Field level managers such as foremen must choose and coordinate their crew tasks in the immediate future.

An important aspect of LPS is that in these cascading duties, going from the general to the specific, each management level must allow maximum flexibility to the levels below. Foremen decide the specific tasks for the week, mainly based on the short-term objectives specified by the superintendent's schedule and the available resources. The weekly task schedule is decided by consensus in face-to-face meetings. The outcome of each weekly work plan is analyzed using simple metrics and direct dialog among crews, so creating an agile information flow.

COMPARING CPM AND LPS: AN ACTION THEORY PERSPECTIVE

It is easy to infer from the previous section that there are many obvious differences between CPM and LPS. The former creates a comprehensive plan using the expertise of a limited number of stakeholders, who meet primarily before the start of the project. This setup is a perfect implementation of the Deliberative Action model. In contrast, LPS creates a rough plan for the entire project, whose detail is expanded for upcoming activities using the pooled expertise of all project management levels. These LPS elements are quite in line with the Situated Action model. However, although the previous section used vocabulary and covered issues pertaining to Action Theory, a more explicit comparison of three crucial aspects is included below.

NATURE OF THE WORLD

The Deliberative Action model regards the world as "fundamentally hostile, in the sense that rational action requires extensive, even exhaustive, attempts to anticipate difficulties" (Agre, 1995). However, the amount of possible ways in which the world can change at any moment is nearly infinite, especially if the assumption is that the change would be for the worst. Since only a fraction of negative possible outcomes can be anticipated by any planning and control system, it follows that all planning and control systems are sooner or later doomed to fail. The "enemy," according to this siege war reasoning, will sooner or later find the unguarded section of the wall or will figure a Trojan horse. CPM literature is full of examples of this guarded attitude: "As changes occur…the need for tight control of cost and schedule becomes increasingly important" (Gould, 2005).

The alternative to the above rationale, keeping the siege metaphor, is that the vast majority of the wall sections do not need to be guarded at all times, and certainly not by the generals. The Situated Action model, exemplified by LPS, assumes that local actors can deal with most of the negative events of everyday life, thus making available more resources to assess the current status, plot a long-term strategy, and attack substantial (and uncommon) problems with full strength.

PLAN UPDATING

Following a Cartesian view of the world, CPM attempts to create a virtual, equivalent and complete model of the work to perform before the project can begin. As in other deliberative model applications, the drawbacks of this approach become most visible at execution time. Natural variations in the assumptions made about productivity, resources, weather and similar factors make inevitable that the plan becomes increasingly removed from the actual circumstances in the field. The traditional solution to the gap between plan and reality is updating the schedule by providing new input to the model to reflect changed field conditions; then, operating on the model until a new optimal solution is reached; and finally, relaying the new plan to the appropriate actors (Johnston and Brennan, 1996).

Using this approach to update a plan, however, is not a simple proposition. Field information must be translated into a symbolic form usable by network computations. CPM offers nothing to guide the analysis of the oftentimes subtle but important factors influencing an update, such as the mutual influence of two simultaneous activities performed in physical proximity. The input ultimately going into the updated plan is the result of more or less arbitrary assumptions made by a few individuals in charge of the updating.

In contrast, updating an LPS plan is virtually a misnomer as this concept is understood by CPM practitioners. LPS does not attempt to create a detailed and comprehensive activity schedule, proposing instead a continuous planning process. This constant plan creation is objectionable from a CPM perspective, because it seems to betray the necessary predictability for procuring resources and arranging for other contractual commitments. However, as discussed before, few practitioners would contest the fact that updating a CPM requires of many subjective decisions, to a higher degree than this method's literature would suggest (Gould (2005), for example, offers an account of this idealized process). The main difference in updating between CPM and LPS is that the latter recognizes the impracticality of a comprehensive schedule and strives to keep the planning team's expertise relevant throughout the project's execution. In contrast, the initial planning team in CPM is disbanded after the baseline schedule is developed, and subsequent updating decisions are made by scheduling experts that, regardless of their merits, will lack expertise in some of the decisions they need to take. The monitoring and updating of a Deliberative Action model plan has been described as "a mechanism for failing safely when things go wrong" (Agre, 1997).

From an Action Theory perspective, plan updating has been recognized as one critical shortcoming of the deliberative model. LPS's situatedness is evident in the recognition that, using Action Theory vocabulary, actors have a limited view of the world, and that the best way to account for this situatedness is to pool up their individual, limited perspective when deciding the next step for the project's execution.

ROLE OF INSTRUCTIONS

Instructions are the interface between the agent intentions set forth in a plan and the actors in charge of executing the plan. Instructions, therefore, play an essential role in the execution of any plan, and are central to Action Theory.

Suchman (1987), among others, makes the point that instructions, as any other cultural artefact, disappear from the forefront of attention when they are routinised. The need to follow instructions, amid the myriad of routine activities in a normal environment, is exceptional. As a corollary, instructions, similarly to plans in general, must be envisioned as resources to manage action, and not as control mechanisms.

All instructions are subjective and incomplete. As Suchman (1987) points out, "successful instruction-following is a matter of constructing a particular course of action that is accountable to the general description that the instruction provides." Recognizing the indexicality (i.e., dependence on the agent's context) of instructions is an essential component of the situated action model. The Deliberative Action model is especially weak in this area. Chapman (1991) considers instructions as an "intractable problem" of this model, since there is a fundamental contradiction in its plan-then-act requirement. This sequence requires of perfectly clear instructions and assumes that plans can be implemented top-down, with actors being essentially replaceable executing machines. This assumption removes the possibility of subjective interpretation, and therefore the independence and initiative paradoxically essential to follow any set of instructions.

The central role of The Plan in the Deliberative Action model also brings a contradictory, absurd problem: it relies on the premise that instructions will be followed, and that instructions will not be followed. Knowing when instructions should not be obeyed is the hallmark of any good manager. While it is true that good managers realize the absurdity of blindly following a set of instructions, it is also true that they will be held liable for breaking the plan if the project is unsuccessful. Johnston and Brennan (Johnston and Brennan, 1996) discuss the case of a school improvement plan which relied on centrally developed plan, with very detailed specifications. The plan quickly proved to be inappropriate for some schools. The school administrators tweaked the specifications, but the plan did not result in the intended improvements anyway. These school administrators were considered "recalcitrant" for not following the instructions provided, and "more training" was suggested to change the outcome. Similar stories could be told by many construction managers or subcontractors needing to perform work in a project with necessarily incomplete and frequently erroneous plans and specifications. Project managers are expected to fill in these information gaps and ambiguities, but are penalized if their interpretation turns out to be erroneous. Such quandary clearly stifles the ingenuity and initiative of many project managers, and yet it is perpetuated by the contractual framework of the vast majority of construction projects.

CONCLUSION

Advocating a position while acting on another is a quite common human attitude. Most people have to some extent a "do as I say, not as I do" attitude, which has been aptly described by Argyris et al. (1980) as the difference between their "espoused theory" and their "theory-in-use." While espoused theories are "those that an individual claims to follow," theories-in-use are "those that can be inferred from action. CPM practitioners exemplify espoused theory. If the world were "just a little different," CPM would be an ideal system. The problem is, it is not.

Many Lean Construction principles are in line with the Situated Action model. The strategies suggested by LPS take into account the situatedness of all individuals executing a project. LPS leverages situatedness instead of fighting it. However, the malleability of the LPS planning process is troubling to practitioners viewing project execution through a traditional, deliberative lens. Although Lean Construction principles have been illustrated using LPS, Lean Construction is much more than this particular system: Jobsite transparency, to mention one of many topics not particularly addressed by LPS, is a perfect example of a situatedness issue of concern for Lean Construction.

Action Theory, and particularly the Situated Action Model, can be useful to visualize some important topics that should be addressed by Lean Construction research. An important topic is the use of digital simulation as a tool in the management of construction projects. There seems to be a tension between the comprehensive modelling required to simulate a construction project and the minimalist approach of Situated Action. This apparent tension could be productive for the analysis of long-standing simulation issues such as the role of simulation for field control and the appropriate level of detail in the model. Among other topics, Action Theory could also offer a framework to study the paradoxical duality of formal and informal management structures (Docherty, 1972), the optimal granularity of milestone plans, or the dynamics of field-level planning. In fact, the limiting factor to the application of Action Theory to Lean Construction research could be its obscurity for Lean Construction researchers and practitioners. A critical next step in furthering the application of this theory, therefore, is a wider of diffusion of its merits in the Lean Construction community.

REFERENCES

Action (2002). Stanford Encyclopaedia of Philosophy [Online]. Available http://plato.stanford.edu/entries/action/, February 3, 2007.

Agre, P. (1995). Computational research on interaction and agency. Artificial Intelligence 72, 1-52.

Agre, P. (1997). *Computation and Human Experience*. Cambridge, UK: Cambridge University Press.

Agre, P. and Chapman, D. (1990). What are plans for? Robotics and Autonomous Systems 6, 17-34.

Argyris, C., Putnam, R. and McLain Smith, D. (1985). *Action Science: Concepts, Methods, and Skills for Research and Intervention*. New York, NY: Jossey-Bass.

Ballard, G., Howell, G. (2003). An update on Last Planner. In J. C. Martinez, Formoso, C.T. (eds) 11th IGLC Conference, Virginia Tech, Blacksburg, VA.

Ballard, G. (2000). *The Last Planner System of Production Control*. Doctoral thesis submitted to the University of Birmingham, UK.

Ballard, G. (1994). The Last Planner. Northern California Construction Institute Spring Conference, Monterey, CA, April, 1994.

Birrell, J. (1980). Beyond the Critical Path. J. of the Const. Engr. And Mgmt. Div., ASCE, 106 (1), 23-25.

Chapman, D. (1991). *Vision, Instruction, and Action*. Cambridge, MA: MIT Press.

Gould, F. (2005). *Managing the Construction Process: Estimating, Scheduling and Cost Control*. Upper Saddle River, NJ: Pearson Education, Inc.

Docherty, P. (1972). *The management of Contingencies*. Stockholm, Sweden: The Economic Research Institute.

Halpin, D. (1993). Process-based research to meet the international challenge. J. of the Const. Engr. And Mgmt. Div., ASCE, (119) (3) 417-425.

Heidegger, M. (1962). *Being and Time*. New York, NY: Harper Collins.

Huber, R. and Reiser, P. (2003). The marriage of CPM and Lean Construction. 11th Annual Conference International Group for Lean Construction (IGLC-11), Blacksburg, Virginia.

Johnston R. (2000). Situated Action, Structuration and Actor-Network Theory: An Integrative Perspective. ECIS 2001, the 9th European Conference on Information System, Bled, Slovenia

Johnston R., Waller, V. and Simon, K.M. (2005). Situated information systems: supporting routine activity in organizations. Int. J. Business Information Systems. 1 (1/2), 53-80.

Johnston, R. and Brennan, M. (1996). Planning or organizing: the implications of theories of activity for management of operations. Omega, Int. d. Mgmt Sci. 24, (4), 367-384

Korman, R. (2004). Critical Path Method. (Cover story). ENR: Engineering News-Record, 252(25), 30-31.

Koskela L., Howell G. (2002). The underlying theory of Project Management is obsolete. Proceedings of the PMI Research Conference, Seattle, pp. 293–300.

Koskela, L. (2000). *An exploration towards a production theory and its application to construction*. Espoo, VTT Building Technology. 296 p. VTT Publications

Koskela, L. (1992). *Application of the New Production Philosophy to Construction*. Technical Report No. 72, CIFE, Stanford University, Stanford, CA.

Macomber, Hal (2002). Critical path method: Fool me once, fool me twice. Reforming Project Management weblog, http://www.reformingprojectmanagement.com/2002/10/04/46/

Ohno, T. (1988). *The Toyota Production System: beyond large scale production* (Taiichi Ohno with Setsuo Mito; translated by Joseph P. Schmelzeis). Productivity Press, Cambridge, MA,

Project Management Institute (PMI) (2004). *A guide to the project management book of knowledge (PMBOK guide). 3rd ed.* Upper Darby, PA: Project Management Institute.

Robinson, M. R. (1965). CPM surveyed. Building Construction, 10 (Dec).

Suchman, L. A. (1987), *Plans and Situated Actions: The Problem of Human-Machine Communication*, Cambridge, UK: Cambridge University Press.

Vera, A. and Simon, H. (1993). Situated action: A symbolic interpretation. Cognitive Science. 17, 7-48.