

Organization Of Distributed Adaptive Learning

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ABSTRACT

The growing sensitivity of various systems and parts of industry, society, and even everyday individual life leads to the increased volume of changes and needs for adaptation and learning. This creates a new situation where learning from being purely academic knowledge transfer procedure is becoming a ubiquitous always-on essential part of all viable organizations, systems, processes and human lives. The form of learning, which becomes an essential integral part of coevolutionary adaptive efforts of individuals and socio-economic entities in their attempts to cope with change, supplements the traditional learn-for-reuse forms. The rapidly evolving new features of learning discussed in this paper form a system determined by their mutual reinforcement and dynamic influence.

Keywords: Learning, Adaptation, Evolution, Learning Organization, Autonomy

1. INTRODUCTION

The growing sensitivity of various systems and parts of industry, society, and even everyday individual life leads to the increased volume of changes and needs for adaptation and learning. This creates a new situation where learning from being purely academic knowledge transfer procedure is becoming a ubiquitous always-on essential part of all viable organizations, systems, processes and human lives.

The increased mutual sensitivity of elements and processes of our world leads to the change in the very concept of “knowledge,” which from being seen as portable and reusable is becoming increasingly and dynamically contextualized. The variety and frequency of changes in such contexts result in the dynamism and often instability of “knowledge patterns” emerging in that context.

The growing need in coping with such situation naturally resulted in the commoditization of learning as a product or, at best, as a portable resource with attempts to borrow the mass production and mass distribution methods designed for prepackaged goods from the past. Meanwhile, “in the last 30 years, virtually every social science and field of humanities has moved away from rationalistic, linear ways of thinking toward an appreciation of multiple perspectives and reasoning in context” [32]. In situated cognition it was shown that learning is fundamentally situated and dynamic in its context development [4,17]. The increasing presence of multiple dynamic contexts not only dramatically complicated control tasks but is a matter of economic, defense, and organizational sustainability and viability. The national ability to develop the new type of workforce education and training, the new types, methods and technologies of learning will determine the possibility of successful growth and development.

In his testimony to the U.S. House Subcommittee on Telecommunication and the Internet [15] Dr. Eamon M. Kelly said: “As the members of this Subcommittee know so well, something new and exciting is happening in the 21st century. We are in the midst of a new era of discovery, learning, and innovation. In the past two decades, our knowledge has expanded at a rapid rate; our world has grown more complex. Knowledge is now the principle source of wealth creation and new jobs in the U.S. and globally. This new knowledge-based economy has brought significant changes with profound implications for society. It has transformed the way we live and work.”

The paper is organized in the following way: after exploring the major problems with the traditional learning organization, part 1 analyzes the specific use, role, and goals of the proposed new type of learning (DAL), part 2 explores the main features of DAL, and part 3 analyzes the synergies of interactions among these features.

2. USE, ROLE, AND GOALS OF DAL

The ability of a business to react to rapid change is the key to their viability. These change oriented businesses are now commonly referred to as “adaptive organizations”. Although several views on adaptive and adaptable systems have been presented either from the adaptive education perspective [5,10] or from the learning design viewpoint [6], there are few LMS that provide standard-based adaptation features [25]. And even when they do, the focus is not on adaptation of the learning itself, but on how to adapt the learning environment to the learner’s goal and capabilities and preserve the traditional learning process in the face of the growing amount of changes in its context and environment.

The form of learning, which becomes an essential integral part of coevolutionary adaptive efforts of individuals and socio-economic entities in their attempts to cope with change, supplements the traditional learn-for-reusable-knowledge forms. We will call this new form of learning – Distributed Adaptive Learning (DAL), which will be the focus of this paper. We will show further the difference of this form of learning from many other known organizational and individual forms, making it a kind of its own.

The specificity of DAL is in a number of various features and methods synergistically interwoven into one new phenomenon. It can be analyzed by the changes in the **use, role, and goals** of DAL (see below) as well as by the type and relationships of the new inner features and properties (discussed in the later sections).

The new use, role, and goals of DAL supporting the integral cycle of adaptation depend on the stage DAL is in. The stages of the learning/adaptation cycle include:

1. **Organization and management of proper DAL forms.** In addition to being tightly coupled with coevolutionary adaptive loops, DAL forms a dynamic learning structure of its own that supports its functionality. This structure can be seen as ad-hoc or permanent “learning clusters” (LCs) that include people, means of IT, forms of automated distributed intelligence, as well as external entities and processes.
2. **Obtaining/choice of the learning inputs.** The created LCs are not restricted by learning from mainly authorized resources for “knowledge transfer,” but use diverse, dynamic, and continuously evolving knowledge sources coming from the dynamically configured sensory network including suggested learning objects, other texts, web and database search, social networks, experiential and active learning and exploration inputs, as well computer-mediated access to dynamically evolving and accessible information. As a result, the incoming information cannot be considered as “knowledge” in traditional sense anymore, but is treated as just information, the meaning of which will be evolved and negotiated across the LC and with the learning environment.
3. **Distribution of the learning results.** Distributed learning is not a process where at the end every LC member attempts to get the same results as in traditional learning. The results of the learning efforts done by LCs should be distributed among its participants according to their participation, needs, views, states, etc. Some will just get the feedback of the type “right/wrong” or “better/worse” (like in reinforcement forms of learning [19]). Some will learn their portion of the new knowledge patterns; some will learn whose opinion to trust more in their LC, and so on. So called “reward distribution” is only one of the problems arising in collective adaptive learning, showing who contributed more to the positive or negative result of the chosen adaptive action. For example, in a collective discussion or a group project some participants might offer incorrect opinions or inadequate actions, but if the message of the success will be distributed evenly – they will think that their learning/acting was adequate and learn the wrong knowledge pattern or skill component.
4. **Local grafting of the distributed learning results.** Instead of simplistic concept of knowledge transfer DAL has to show the ability of continuously assessing and improving the adequacy of knowledge, removing, adjusting, creating, and evolve new knowledge patterns, meanings, concepts, etc. This is

disruptive creative learning without absolute power of celebrated knowledge creators but based on adaptive evolvability of knowledge grafting into the existing systems of meaning. It uses continuous reevaluation of existing, incoming, and personally created meaningful results.

5. **Use of the learned skills and knowledge patterns.** The integral character of adaptation and learning in DAL leads to more complex goals of learning and its uses. Since DAL is embedded into cycles of adaptivity, properly acting on the learned results is another problem, exacerbated by the need in the following learning on acting, and so on. In addition to the use of emerging but somewhat familiar methods of learning like experiential, active, social, and distributed there is a need in continuous reactivation of the adaptation cycle with accompanying coordination among the LC members, learning distribution, and putting the results of learning by different parties together for adaptivity and relearning.

3. FEATURE SPACE OF DAL

The specificity of DAL is based not only its changes in the use, role and goals, but also on the way it is organized internally in terms of the main system-determining features.

Of course, these features are not the only ones that could be found in DAL, but are the most important ones determining the special character of this type of learning and are the ones requiring new forms of their organization and management. They include:

1. The **distributed nature** of DAL organization and the learning itself.
2. The intrinsically **adaptive character** of DAL
3. The **evolvability** of DAL organization and knowledge/skills resulting from it
4. The gentle management of DAL seen as a **dynamic balancing of autonomic self-organization and more centralized guidance**, which is better be called “gardening” rather than direct control.

3.1 Distribution of learning

The complexity of learning distribution in DAL goes beyond the notion of learning clusters. Distribution in DAL can be seen as a rather general property including a variety of lower-level features like enhanced learner autonomy; end-user empowerment; proliferation of virtual teams, virtual groups, and dynamically distributed learning administration; and adaptive actions of the autonomous learners. It also includes forms of distributed cognition; distribution of learning services and functions among humans and elements of distributed artificial intelligence; and distribution of administration and leadership roles. All of these features can dynamically change and have to be rebalanced in self-organized or guided manner.

Distribution is a dynamically balanced combination of learner’s autonomy with some coordinating communications. The need in and importance of learner’s autonomy have been discussed in [3, 14, 20, 30]. The importance of empowered autonomy has to be balanced with some coordination mechanisms [21, 22, 23], where autonomy and control are not in direct trade-off competition but rather represent different levels of the overall organizational adaptivity. Autonomic learner can be an individual, a group, an LC, or the whole organization, participating in a bigger virtual organization.

The latest research in psychological, sociological, and organizational mechanisms of distributed learning indicates the complexity of the involved process as well as richness of the collective feedbacks. Sitter [28], following Ashby [2], sees the need for socio-organizational forms restoring the match of the external complexity by the adequate growth in internal complexity and distribution. Organizational learning [27, 1, 13] attempts to find the proper level of internal complexity of relationships and interactions matching the variety of organizational problems. The concept of *group learning* cannot be attributed to any one advanced learner or even to a division of labor in which different persons contribute different pieces of the product. [9]. In addition to behaving as an independent learning agent, clusters of learners create their own networks that coevolve with group and individual learners [12] in a series of multilevel feedbacks. These ideas of situated learning were enhanced lately [17] with the addition of concepts of situated action [24] and distributed cognition [16]. The theory of distributed cognition (DCog) studies learning and cognition in a broader process of using external environment as an extension of the learning processes.

3.2 Adaptivity of learning

Adaptivity as a DAL feature is broader than only adaptation to the new technologies, but also includes dynamic learner adaptation to the sources of information, goals, contexts, and changes in stakeholder situations. At the same time adaptive features of DAL can be seen as a method of learning as compared to being a form of protecting the existing learning design from environmental changes.

The novelty of this feature is in the degree of shifting away from preplanned learning design to a more responsive, embedded, and dynamic development of learning processes in their essence and organization. Adaptation is rooted in continuous reevaluation of the changing situation and adequacy of external behavior and learner/LC changes. For example, it requires continuous re-evaluation of the adequacy of the “obtained knowledge” when some parts of it have to be amended, forgotten, dramatically changed, or kept stable. This is a different culture of learning/re-learning when coevolutionary adaptive adequacy balanced in the strategic and tactical dimensions becomes the only trusted teacher.

Another aspect of DAL adaptivity is in the maintenance of the adequacy of mixing/balancing of its own features and external behaviors. Such balancing might be required not only after switching from one project/course to another but during their offering. Therefore, adaptive learning includes adaptation of the features and parameters of learning as a process and organizational structures that could be self-organized or guided by adaptive administration in its various forms. Such double-loop adaptation also incorporates its own double-loop learning.

3.3 Evolvability of learning

If adaptive features of learning seek adequacy of the learning goals, results, and organization to the changing parameters of the learning situation and often can be achieved by activating one response scenario out of several predesigned, such feature as evolvability requires the ability to dynamically create and creatively destroy inadequate features, parameters and results of learning. Re-learning of the material which is no longer current and might even become incorrect is one of the components of learning evolvability. It obviously has different methods and goals of learning where memorization-for-reuse is not an option and might even invalidate the adequacy of a learner to the changing situation. New methods of critical revision, reconstruction, reintegration, readjustment, and weeding out the previous learning results become important.

Knowledge management is seen more and more as learning management and adaptation to the changing environment. In complex systems the proper administration is based on the quality, ease, cost, and speed of just-in-time (JIT) and just-what’s-necessary (JWN) learning and immediate acting based on whatever has just been learned. Patterns of knowledge dynamically evolve from the context of learning situations and have to be rapidly mapped into adequate plans and current behaviors.

As with discussed above adaptivity of DAL, its evolvability feature has a number dimensions being a general position. Evolvability can refer to the internalized knowledge patterns and systems, to the structures and functions of LCs, to the whole organization of DAL as well as its various aspects.

The structural evolvability of LCs and its dynamic relations with its members can be seen in Actor-Network Theory (ANT) framework studying the mutual coevolution of individual actors and networks as different types of entities. An actor is seen there in a more general sense as "any element which bends space around itself, makes other elements dependent upon itself and translates their will into a language of its own" [8]. In addition to seeing actors and various forms of networks as legitimate learning entities in their own right, we can note that they form a joint dynamic multilayer system constantly redefining each other and depending on the other [7].

The evolving nature of individual communications is based not only on reasoning but also on various forms of perceptual and interpretational activities [11, 26, 29]. The collective intelligence in LCs requires continuous feedback interactions for its development and effectiveness [31].

3.4 Self-organization and harmonization of features

Although uniting into various learning clusters for increased efficacy of learning and adaptation, the participating actors might have different and even conflicting interests (e.g. peer-to-peer problems; customers versus providers; relationships among various types of intermediaries, service providers, integrators, resellers, etc.) and attempt to maximize local utilities. DAL has to be able to balance the interests of local self-organization and utility optimization with global minimization of possible tensions and harmonization of the overall learning ecology.

If harmonization of tensions among participants of LCs has roots in theory of coordination and cooperation, the more general balancing of the high-level dynamic features of LCs requires higher-level abstractions. They have to address the problems of balancing-mixing of degrees of distribution and autonomy, adaptivity versus strategic stability, levels of evolvability versus the use of predetermined tools and methods, as well as a number of other subordinate and derived trade-offs. This level of DAL support given the need for maximizing self-organizing autonomic behaviors has to be administered in a gentle “gardening” style approach versus control methods. The interval/diapason between lower level conflict resolution in various specific situations and high-level systems gardening is in itself an object of DAL application. The task of DAL management is in dynamic balancing of autonomic control, hierarchical management, lateral influences, and self-organization for all learning entities (including various social structures).

4. RELATIONSHIPS AMONG CORE DAL FEATURES

The proper support of the described needs of DAL requires a coordinated and integrated effort of a number of methods and technological capabilities currently existing and under development in the areas of human and machine learning and knowledge management. They could be clustered into groups simultaneously reflecting the described above DAL features/capabilities as well as technological and methodological areas supporting those needs.

Although, each of the described features has been known before and used under various circumstances in academic and industrial environments, the specificity and previously discussed capabilities of DAL can be seen in the integral nature of these features. Distribution, adaptive exploration, evolvability, and supportive guidance (in the place of control) in the sense discussed in the section above form a type of learning not only forming a central behavioral core in modern coevolutionary adaptive dynamics in modern organizations, but also rapidly becoming a dominant type of capabilities that an organization prefers to get from ICT implementation. (most managers emphasized higher importance of communicative distributed decision-making versus knowledge management role of IT).

Schematically the basic triangle of capabilities influencing each other (see fig.1) includes the handling of the problems of distribution, continuous evolvability of knowledge, and methods of active knowledge elicitation **or** adaptive exploration. The center of this triangle is occupied by the need to be able to effectively perform all these activities in the presence of diversity of interests ranging from very cooperative, to indifferent, dynamically changing, competitive, and even antagonistic. The top of the pyramid is taken by the double loop learning as learning design management allowing to tweak and tune learning design (LD) so that all previously described functions will work in the most effective and efficient way.

An important feature of DAL pyramid is in close relationships among distribution, evolvability, and adaptive exploration allowing to solve variety of combinations of problems in DAL environments. Thus the learning adaptation is largely based on autonomic actions of the learners and other members of LCs, the evolvability is a result of autonomic adaptive actions as well as collective behavior of the LC members, and adaptive behavior is not only the basis of distribution and evolvability but has to shape them into one coherent integral complex.

The support for these features has to be designed in a very interactive and dynamic fashion. Minimization of tensions is a more specific and standalone problem, which is usually approached via special multi-agent systems, game theoretic, market-based, and other methods allowing for conflict resolution and minimization of tensions.

Managing learning design takes a special meta-role as learning the way learning and its application is going on and tuning the whole learning design in order to support its workability and efficiency.

We suggest that the proper administration of complex learning processes should include the complete set of the presented above learning capability classes and support their dynamic and mutually cooperative relationships (see fig. 1).

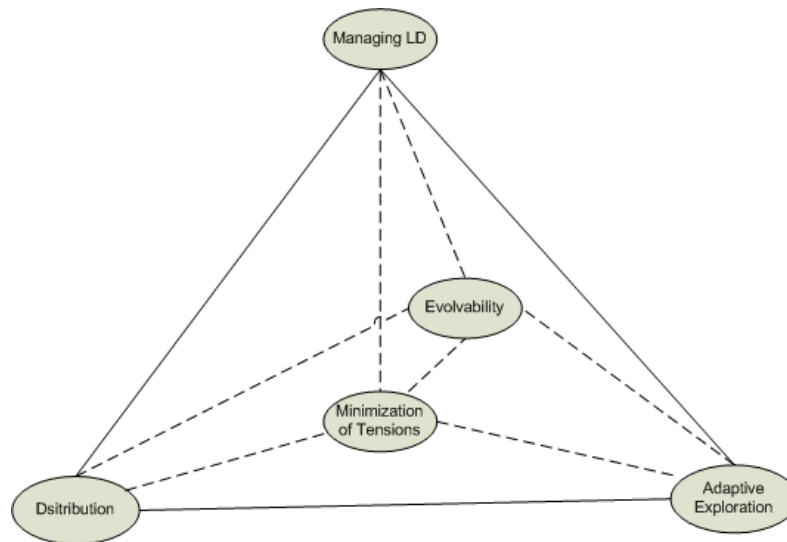


Fig 1. Core features of DAL

The architectures and processes of new administrative systems should explicitly deal with these capabilities and reflect their functionality and interactions. Of course, the degree of complexity of the solutions should be adequate to the complexity of the system, yet allowing for easy scalability in the described features and their interactivity.

CONCLUSION

The importance of recognition of this type of learning with its specificity will allow for the development of the necessary implementation, administration, and research aspects of it. The situation when the forms of traditional learning organization are not only poorly applicable to DAL but often hamper its development, has to be recognized allowing for special treatment in global regulatory and local tactical implementations.

The formulation of DAL as a research domain will allow for synergies between adaptive workplace and academic learning organization as well as between human, semi-automated, and fully automated forms of learning with more aggressive use of ICT and AI means. Although the traditional form of learning with its knowledge transfer-for-reuse definitely has its uses and subjects, in a number of cases (like the ones previously explored) it has to be supplemented or even replaced by DAL.

DAL, as a special type of learning development, organization, and administration, is more useful than traditional learning in the situations when coevolutionary adaptation is more important than steady control and underlying model stability. Being used and taught in educational organizations, it closes the gap between the knowledge and skills of organizational change management efforts and striving for fundamental knowledge that dominates academic institutions.

The path of increasing real world value of education versus “established academic standards and principles” by using new forms of learning like DAL that close the gap between workplace/workflow forms of learning embedded in organizational adaptive cycles and academic learning for “knowledge-to-go” might show another way of increasing return on learning investment for the country, organizations and individuals.

The closeness of the industrial and academic goals and methods in DAL might allow for the increased role of internships and joint student-employee projects as a higher penetration of educational organizations into the ongoing needs in organizational learning. This in turn might lead to a different source of academic funding when in addition to the government sources and student tuition (as strategic investments in the future) they will use funding from business and non-profit organizations that use joint ventures and ongoing collaboration with educational organizations in DAL formats. This, in turn, might lead to selective certificate (and even degree) programs administered through special profit centers in higher-education institutions.

The contributions of our paper are threefold. First, we formulate the problem of inadequacy of the traditional form of learning and understanding of its essence. Second we analyze the needs in changes of use, role, and goals of learning. Then we formulate the existence of a new type of learning (DAL) meeting these needs. And finally we formulate its distinctive features of DAL and analyze their interrelationships.

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