# Key Challenges in the Design of Learning Technology Standards – Observations and Proposals

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## ABSTRACT

This paper considers some key challenges that learning technology standards must take account of: the inherent connected-ness of the information and complexity as a cause of emergent behavior. Some of the limitations of historical approaches to information systems and standards development are briefly considered alongside generic strategies to tackle complexity and system adaptivity. A consideration of the facets of interoperability – organizational, syntactic and semantic – leads to an outline of a strategy for dealing with environmental complexity in the learning technology standards domain.


*Keywords: complex adaptive systems, shearing layers, de-centralized, semantic interoperability, learning technology standards*

## THE CHALLENGES OF LEARNING TECHNOLOGY STANDARDS

Many workers in the field of learning technology (LT) standards have a sense of dis-satisfaction at the amount of progress made to date, reflected in the call for papers of this special edition: "a growing awareness that standards experts and bodies have to improve both their processes and products" (Hoel, Hollins, & Pawlowski). It is, however, far from clear that other fields of IT standardization have made proportionately greater progress when considering the relatively small number of workers in the learning technology standards world. This paper considers some of the challenges arising from the character of the education system that future LT standardization must overcome or circumvent if desirable levels of future progress are to be made. In this paper, the word "standards" is used, not only for *de jure* standards, but for virtually any multi-laterally agreed set of technical conventions.

## An Engineering Heritage

In the early stages of the development and use of the electronic computer, the biggest challenges were in the realm of engineering. Hardware, Operating Systems, compilers, data stores and programming languages/paradigms have all been developed to a phenomenal degree through engineering and use of objective measures of performance. In spite of early recognition that IT systems are not simply mechanical – they are socio-technical - in character, computing courses have generally continued to reflect the engineering heritage.

From the late 20th century, it has become progressively more clear that failure to account for complexity and socio-technical factors is severely limiting the effectiveness of ICT interventions and organizations(Bullock & Cliff, 2004) (Mumford, 2000). The recognition of this problem is not, however, a solution; the solution is hard and we live with the challenge of moving on from our engineering heritage in LT standardization as well as in IT systems design.

## Connectedness of Concepts and Unknown Bounds

"Connectedness" is used to express the idea that almost anything that is the subject of a communication, i.e. is information, could also be the subject of a communication with different intent and effect. Any boundary around a collection of concepts is arbitrary. At best it is a commonly-adopted convenience, commonly it is an un-conscious artifact of a particular application or context, and at worst it is an insufferable impediment. When there is a high degree of uniformity in, and dominance of, a process, the "commonly adopted convenience" becomes a cause of greater efficiency and it may be possible to package the whole as a standard. In the absence of dominance and uniformity, a conscious and reflective set of compromises becomes necessary.

The challenge for learning technology standardization is that the dominant and uniform processes are generally either not there or not easily seen. The typical case seems to be that any information about subject is used in many ways. For example, information about the content and structure of a university course appears in numerous processes/activities, each claiming some kind of authoritative status: design and validation, marketing, management information, e-learning platform, diploma/transcript, etc…. This appears as a general feature of information systems and is a problematical one if the large number of person-years spent on integration projects - where the consequences of un-conscious and un-reflective compartmentalization are partially compensated for - is taken as a measure.

There are some exceptions to this general challenge, counter-examples where there is a sufficiently isolated sub-domain and cost reductions that make for a proven business case. The most clear counter-example is content/delivery-platform interoperability in aviation maintenance and military training where the case for formalized approaches is clear (Jeffery & Bratton-Jeffery, 2004); a platform from which ADL SCORM could become widespread.

## Complexity of the System

The education system is, of course, not an isolated system. Through the action of individuals, technology and social practices bleed-in to education from general civil life. Its inextricable binding into the social, political, technical and economic structures and collective intentions, combining elements of control, choice and autonomy, suggests that it should be considered a social enterprise.

Compared to a business enterprise, the workings of the education system as a whole are rather more messy but it is worth considering the response of the business IT world to its far-from-simple environment. Historically, the problem of engineering IT in the business enterprise has been seen as a complicated task and approaches under the banner of Enterprise Architecture (EA) developed to increase the effectiveness of business IT developments. The inspiration for EA, according to John Zachman, the man credited with inventing it, arose from industries such as building and aerospace (Zachman), where the scale of operations had been previously overcome.

*Terminology in this section*

| Term Used | Character |
|---|---|
| Complicated | Comprising many parts but these may be broken down into and built up from independent parts. The whole may be understood as the sum of the properties of the individual parts. |
| Complex | A system of many parts that displays emergence. They may be stable, resistant to external change, or enter states where chaotic instability occurs. |
| Emergence | Emergence denotes properties and behaviors of a collection (of many) that differ in character, not just scale, from the properties and behavior of the components. |
| Adaptive | The system is not static but changes its structure in response to its environment. The same environmental stimulus does not necessarily lead to the same system response each time it occurs. |

As time has gone on, the business world has become more complex and the problem of IT alignment to business need has presented business with more than a complicated engineering problem. One reaction to this change has been a move to see Enterprise Architecture as being more related to business strategy (Ross, Weill, & Robertson, 2006). This view emphasizes the identification of the core repeatable processes *vs* those aspects of business operations that add value, i.e. competitive advantage.

More recent work is beginning to recognize, describe and model the complexity in the non-core rather than only identifying where the repeatable, stable and predictable processes occur (Paich & Parker, 2010). Increased interest in the “non-core” reflects an increasing motivation to understand

and anticipate change rather than just to seek efficiency. The issue is that the market-place has become more complex and that change is less uniform, harder to predict. ICT and "the web" has radically reduced the transaction costs for business-to-business interactions and enabled greater customer-to-customer and commentator-to-customer communication. More recently, Cloud computing "infrastructure as a service" has significantly lowered the barrier to entry for innovators and enabled them to rapidly scale-up operations by incremental pricing models and instant availability. The ready availability of these services has the potential to dramatically increase dynamic behavior and overall system adaptivity.

The consequence of this is that network effects have become more important in ways that go beyond value creation by a multiplier effect; networks behave in fundamentally different ways, they show emergent behavior (Bullock & Cliff, 2004).

Education is not isolated from these changes and has a supplementary problem: the scope of the enterprise is less well defined. This is illustrated by the example of efforts to expand work-based learning, where good intentions supported by cogent arguments for social and economic benefits have often failed to translate to success in practice. The map of stakeholders, their differing values and intentions, effective levers for change, their roles and relationships is messy: learner/employee, education institution, employer, professional/trade skills authority, government, funding agencies, etc.

## Culture and Diversity

Educational practices and values are often quite deeply embedded in culture. In part this reflects about 1000 years of continuous existence for some universities but the sheer durability of practices dating back to the academies of ancient Greece, in the "Western World" at least, is remarkable. In the face of this, it seems surprising that there are significant differences between the organization of education among the countries of the European Union or between the United States of America and any EU state. "Significant differences" could also be expressed by saying that there is limited organizational interoperability.

Regional differences are a reality that must be accommodated. An ideal approach to learning technology standards should naturally and efficiently accomplish this objective. In contrast to complexity, this objective is widely apprehended and it will not be further elaborated upon.

## Pedagogy

Pedagogy presents a particular problem for education. On the face of it, it seems that variation in the organization of education is more noticeable than differences in the pedagogic practices of lectures, essays, exams, presentations, seminars, discussion, problem-setting, reading etc… Beneath the surface description of these practices differences become more important: the pedagogic role of the activities differs between contexts and cultures. Furthermore, our understanding of the nature of learning and its relationship to the environment of teaching and technology is generally descriptive, lacks explanatory or predictive power and fails to account for its inherent complexity (Sharples, 2009).

Blandin makes the case that existing standardization practice and process, while intending to be neutral to context and culture, is actually incorporating "peculiar representations" of pedagogy and culture (Blandin, 2004). We need to find some way of dis-entangling these aspects and enable diversity while recognizing that differences of pedagogy are often latent in practice and poorly understood from a scientific perspective.

# DEALING WITH COMPLEXITY AND ADAPTIVITY

Complexity and adaptivity – the idea that agents in the system interact and evolve according to their environment and consequently change the nature of the system – make it difficult to predict the behavior of a system. It is not sufficient to break it down into small parts, each of which can be independently addressed, as is possible for merely complicated systems.

## Organization

Command-and-control approaches to managing, forming or exploiting complex adaptive systems either fail quickly, if the necessary information and system-understanding is lacking at the centre, or fail slowly under increasingly burdensome efforts at coordination and performance monitoring. Similarly, planned approaches fail due to plans that mis-understand the context or become bogged down in requirements gathering and study.

To deal with complexity and adaptivity, we need better ways of organizing our activities and institutions – principally decentralized models for planning and action - and to build-in the capacity for change. De-centralization is a general principle for dealing with complexity (Bullock & Cliff, 2004) and is not just about more people commenting and contributing; it is fundamentally about smaller and non-hierarchically-arranged self-organizing units with a greater capability to respond to signals from the environment.

## Shearing Layers

Organization gives us the capability to apprehend change and to be concerted in our intentions and actions. "Shearing Layers", coined in relation to building design and architecture, is a metaphor to express the idea that changeability should be designed in to what we create. Enabling differential rates of change between the various components of a structure so that the whole does not have to be rebuilt is the goal of shearing layers. The idea has been applied to information systems design by IBM Research (Simmonds & Ing, 2000) on the grounds of similar observations – prevalence of discontinuous and unpredictable change and a view that enterprises are emergent organizations – to those made in this paper. Wilson and Velayutham interpreted and extended this argument in relation to educational technology systems (Wilson & Velayutham, 2009).

### Understanding: Models

Complex Adaptive Systems may be difficult to predict and counter-intuitive but this does not mean that they cannot be understood. Models can be built and calibrated (Paich & Parker, 2010) but adaptivity is particularly challenging as time-dependent data is required for model-building and calibration. There has been little application of these kinds of modeling techniques in the education domain, although some work (Sklar & Davies, 2005) shows promise for this as a research topic.

Model-building operates at the level of most detail and is laborious; for the present time we should expect to use "Organization" and "Shearing Layers" to compensate for the deficiencies in our understanding.

## PERILS AND PITFALLS

### Learning Technology Architecture

Learning technology is a young concept at the intersection of the complex social enterprise of education and the rapid change of technology. The paradigmatic shift that is "the web" is still being played out and descriptions of its social and economic consequences continue to reveal new complexity and explanatory perspectives.

Attempts to define or describe an architecture for learning technology have been largely thwarted by change and difference of opinion arising from embedded cultural, technical or pedagogic perspective. These assumptions were either wrong or the cause of bogged down requirements gathering and study: out of date, inaccurate anticipation, recognized inadequacy, cause of dispute, etc…

The nature of the system, complex and adaptive, means that the architecture for learning technology is largely emergent. It may not be completely analyzed, anticipated or planned, although analysis, prediction and associated discourse are part of the process of emergence. Description and value-judgment as part of this discourse form a feedback loop that influences, but does not directly control, the emergence of the architecture. Description is part of the system.

The situation described above is a challenge to any would-be standards-maker; to decide where and how to make a standard, we need some view of architecture. This can be split into two: infrastructural and application. The "architecture of the web" (Jacbos & Walsh, 2004) is clearly the infrastructural architecture for 21st century interoperability standards, quite a low-level description and a long way from an application architecture. This gives us a stable foundation and its adoption will improve the success that can be achieved from applying de-centralised organization and "shearing layers" to deal with the emergent application architecture.

## Anticipatory Standardisation

Anticipatory standardization has been identified as a necessary precursor in situations where products and services are only viable given a network effect but the causes of success and failure in anticipatory standardization are complex and poorly understood (Lyytinen, Keil, & Fomin, 2008). Telecommunications is the most clear domain where anticipatory standardization is necessary but it was also necessary for web standards to be developed in anticipation, although this was a process with many failures and false steps. Great care is taken to ensure that the low level protocols do not interfere with innovation and evolution but inevitably future innovation has to work around the limitations up to the point where a step-change occurs, as in mobile telephony "3G" networks. Whereas the products and services are strongly influenced by complexity and adaptivity, the low level standards are insulated (but not isolated) from these influences and are more suited to anticipatory standardization.

Anticipation at the level of products and services, where learning technology operates, must be undertaken with a recognition that it will almost certainly be wrong without sense-making of potential futures and negotiated description of them. Whereas step-changes in infrastructural standards and technologies are seen to occur (3G, XML, …), overlapping, phased, drift with incremental innovation and anticipation by degree is the rule within educational institutions as it is in the "perpetual beta" world of 21st century web applications. In learning technology standardization we should anticipate with care: the business case is difficult and the recipe for success unknown.

## CONCERNING FACETS OF INTEROPERABILITY

Interoperability is generally viewed as being separable into syntactic and semantic interoperability. Organizational interoperability seems to have received early attention in relation to coalition warfare – e.g. (Tolk, 2003) - but now receives more general attention (Baird, 2009); this paper considers interoperability to be multi-facetted capability comprising organizational, semantic and syntactic interoperability. For education, a social enterprise, considerations of organizational interoperability – expectations of operational protocols, objectives, authority, etc - are not restricted to the educational establishments and must include ideas of social norms and values.

Each facet has different temporal properties, different sensitivity to network effects, etc … and consequently a different implication for standardization, which relies on identifying points of stability. The following table suggests some key differences for the education domain:

*Facets of Interoperability*

| Facet | Stability | Implication |
|---|---|---|
| Organizational | The organizational structure of the education institutions is characterized by relatively stable differences, although some observers question the viability of existing models in the current social, technical and economic environment. | Diversity must be accommodated. |
| | If, however, we consider organizational interoperability to extend to the relationship between institutions and learner, significant and potentially disruptive changes are occurring. | Effort is needed to balance the supply- side (institutional), which often dominates standardization with the demand-side |

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|---|---|---|
| | | (learner) requirements. |
| Syntactic | Syntaxes become stable given sufficiently wide adoption and will be resistant to changing conditions, forcing the effect of the change elsewhere. In the early stages of adoption, competition is likely to add to the churn caused by environmental change. | The syntactic part of a standard, comprising the grouping of elements and their encoding must be changeable. |
| Semantic | Day-to-day activity tends to operate with implicit and surface semantic units and these lack stability. Working at this level will produce standards with poor semantic interoperability. Beneath the surface, there are core semantic units that are relatively stable. | Effort should be invested in identifying the stable, core, semantic units and standards should be built around these. |

Twitter (http://twitter.com) is an example, albeit outside the standards or education worlds, of a phenomenon that illustrates some of the above. It's organic growth in a sub-culture is predicated on a large degree of organizational interoperability within that sub-culture. Twitter's simple message syntax, for example "@username" to indicate a tweet is directed at a particular person, is now so well embedded that it is leaking out into other text-based communication such as email. On the face of it, Twitter introduces new concepts such as the "tweet" but this is a surface concept, too closely bound to a manifestation of a communication act. Beneath this thin veneer of novelty lies a broadly-applicable set of semantic units applicable to public communication acts that could be applied to email lists, web forums, blogs, etc... What differs between these are the constraints, structures and collections and, significantly, norms of behavior: organizational interoperability.

## CONCLUSIONS FOR LEARNING TECHNOLOGY STANDARDS

In essence: LT standards should be developed to accommodate diversity and change and to be part-of the systemic processes from which learning technology emerges. This has two parts: the organizational aspects of standardization and the technical aspect of how standards are written. We can see this as a kind of formative evaluation; considering where we are now but looking into the future in recognition that no point in time has privileged status.

Learning Technology standardization, while learning ways to accommodate diversity and change is likely to succeed where change is least, in those areas that are least susceptible to change. These are where there is a higher probability that investment is justified; where there is a "business case". The challenge, in targeting activity, is not to cut ourselves off from the future by failing to build-in shearing layers and not to box ourselves in to single-application standards.

## Organizational Aspects

De-centralized planning and action is partially a feature of the existing learning technology standards system but closer inspection reveals some limiting characteristics.

Learning technology R&D should be a good vehicle for de-centralized planning and action but neither public nor privately funded R&D is effectively integrated into an overall standards system. In addition, public funding program scoping and contracted obligations often impose a filter and constrain agility. We need to find better ways to harness R&D without assuming that its products are necessarily fit for purpose.

Research communities and industry consortia should fulfill a coordinating role, a higher order of structure in the de-centralized model. Well-established research communities exist but they are less successful at coordinating action than they are at supporting dissemination and networking within the community. On the other hand, industry consortia that behave as competitive enterprises reduce their value as coordinators in a de-centralized approach.

Public standardization (national standards bodies, CEN and ISO) impose a hierarchical structure and a highly regulated process. This structure works well to ensure fairness for mandated standards and particularly well for standardizing goods with well defined purpose – e.g. domestic waste pipes – but is ill-suited to the complex and inter-connected education domain. They have a role along-side more adaptive and de-centralized structures, from which the more stable and widely-relevant specifications can migrate.

## Technical Aspects

The principal requirements, to accommodate diversity and change, should be met by similar or identical methods in the interest of efficiency and viability.

The "shearing layers" metaphor is well illustrated by building and architecture; foundations, superstructure, partitions, services, fittings and furniture form part of the whole in ways that reflect the speed of change people seek in their domestic or workplace environment. The same structural relationships also naturally support diversity and do so in an economical way if different elements can be composed in a modular fashion.

Bearing in mind the observations made on the facets of interoperability (above), and adopting the shearing layers metaphor, it is proposed that learning technology standards should be developed in a layered and modular style with core semantic units as the stable foundation and following the principles of web architecture (Jacbos & Walsh, 2004). The layers of the specification should build up from the general to the specific and each should have a well-defined and consistent shearing plane so that higher-up layers can change, or alternatives can be added, without disrupting the lower one.

*Proposed layering in the structure of standards:*

| Layer | Character | Stability |
|---|---|---|
| Conceptual Model | Conceptual models relate to the way people conceive of things and their relationships independent of the way instances of those things may be described. They are abstractions over existing practice that draw out the essential similarities. They are shared within communities but may not be universal. They are application-neutral and usefully extend beyond the bounds of the specification that is to be written in order to situate it in the wider landscape. | Most stable if well executed; the concepts described are independent of the description. |

| | | |
|---|---|---|
| Identified Semantic Units | The types of thing (classes) along with the properties and necessary value-spaces that will be used to describe them are enumerated and explained in relation to the conceptual model. These may be newly-defined or references to identified semantic units from other sources. All should be uniquely identified. | Slightly less stable as different groups will define different units for essentially the same concept. |
| Assemblies | The semantic units are assembled to specify how things are to be described, i.e. how the properties, classes and value-spaces fit together. | Different applications and changing requirements alter the description. |
| Encodings/ Syntax | These comprise the necessary binding to a method for exchanging the information in practice. Multiple bindings allow diversity of platform, for example JSON, RDF/XML, XML, LDAP, microformats, … | Variable |

## Combining the Organizational and the Technical Aspects

There is a sensible correlation between the organizational components and layers outlined above. This suggests that we should target the public standardization bodies with specifications at the more stable layers, accommodating as much diversity as possible through the range of bodies concerned. A role for research communities and industry consortia could usefully be developed in sense-making, teasing out the general from the specific, winnowing the viable from the un-viable and clarifying the shearing layers; initial R&D will inevitably not – and should not – take such a purist approach.

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