Rethinking Life-long Learning: The Empirical Modelling Approach

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Abstract

Educational technology is seen as key for life-long learning, but it has yet to live up to expectation. We argue that current learning environments are typically oriented too much towards structured learning to meet the needs of the life-long learner. Environments for life-long learning demand a higher degree of autonomy for the learner, must be open to eclectic sources, support soft informal learning activity, and accommodate evolution both in the experience of the learner and in the context in which this occurs. We propose sense-making through the construction of suitable interactive artefacts as a core activity for life-long learning, and briefly discuss and illustrate how this can be supported using Empirical Modelling.

1. Introduction

The term 'life-long learning' has become prominent within the educational community and in government proposals. In the UK, the Secretary of State for Scotland has declared that "Life-long learning is a feature of modern life and will continue to be so" [10]. The epithet 'life-long' is somewhat difficult to interpret, as - to judge by its application! - it can refer to all kinds of learning - encompassing pre-school, school, higher and further education, as well as both formal and informal learning. For the purposes of this paper, 'life-long learning' will be taken to mean *learning activity that takes place as a part and expression of living*. This accords with the popular archetype for life-long learning: adult education outside the schooling years through work (e.g. in training courses) and also for pleasure (e.g. night classes, etc). It also embraces the kind of unsupervised, self-motivated learning that is associated with over-a-lifetime learning of specialist disciplines, hobbies and skills outside the classroom.

The role that educational technology can play in supporting life-long learning has yet to be clarified. There are reasons to suppose that current technology is well-suited to supporting independent learning activities on the periphery of established educational frameworks, but optimism is tempered by the knowledge that educational technology has yet to live up to its expectations within these frameworks. This ambivalence about the potential of technology is reflected in the observation by the British Educational Communications and Technology Agency to the effect that: “There is some evidence of the use of ICT in traditional teaching, and some blended learning is taking place. However, ICT and e-learning are still largely peripheral to classroom teaching and are most widely used for additional support activities to extend independent learning” [11]. The limitations of current models for e-learning are confirmed by recent research findings revealing that greater online interaction does not significantly improve student grades [5]. Though there has been a trend towards many more online students and classes, there have also been exceptionally high drop-out rates - up to 80% - for online courses [4].

This paper argues that adapting the traditional e-learning environment to support life-long learning is exceptionally challenging because of the mismatch between the characteristics of life-long learning and the underlying model of knowledge behind conventional computing platforms. In some respects, a more appropriate orientation is found in the computing technologies behind recreational activities such as game-playing (cf. [7]), digital photography or electronic music. The principles that are emergent in these technologies have yet to be properly recognised, and are in tension with the established framework of computing. And whilst the thinking that underlies classical computer science suits the instructionist metaphor, an alternative vision for computation is needed to liberate the constructionist ingredients essential for life-long learning. Building on critiques of conventional programming in support of constructionism [2], this paper advocates model-building based on Empirical Modelling (EM) principles as an alternative approach that is particularly well-suited to the demands of life-long learning.

2. Technology and life-long learning

Technology as a medium for communication is the current driving force behind life-long learning. There are two aspects to this communication. Computers have become popular for the distribution of information since the birth of the World Wide Web, and are now commonly used as resources of downloadable course material. Developing web resources is perceived as enabling learning outside the classroom, allowing learners access to information in an ubiquitous manner. Computers have also been used for two-way communication in environments where students and teachers can interact. Such communication in support of e-learning can be synchronous, asynchronous or a combination of both. For example, a teacher can communicate with a student by email or organise an online session to instruct many students at the same time. This potentially provides universal access for learners to teachers and virtual classrooms.

Organised learning activity that exploits technology as a communication medium in these ways is not well-matched to the needs of the life-long learner. Typical e-learning environments are best-suited to supplying the framework for the systematic exposition of a discipline. Such environments perform best where the learner 'begins at the beginning' and follows the prescribed learning paths sufficiently conscientiously to enable the system to build up a useful learner profile at every stage. Ideally, it should be possible for the learner to enter the framework at any point without having to incur a large overhead in supplying the contextual information about their learning status that is required by the system. In practice, any customisation of resources to the learner has to rely heavily upon the previous history of interaction with the learning environment. This has proved to be one of the problematic issues for e-learning environments, accounting for the frustration felt by learners who wish to engage with advanced topics, but are first obliged to perform routine exercises in order to inform the system of their status.

In the context of life-long learning, the casual use of the internet both to acquire information and to use or download interactive 'learning objects' has greater promise as a model for e-learning. Though the web does not necessarily provide the electronic analogue of an accredited teacher or secure classroom, nor the structured framework of a school curriculum, it meets the needs of the independent learner in some respects. The choice of resources offers the opportunity for self-directed learning; material is generally more self-contained and can be accessed and adapted as required; the range of perspectives represented can be rich and wide. As in "the university of life", these potentially dangerous characteristics are virtues for learners with the appropriate level of discrimination and experience. The limitations of the web as a medium for life-long learning relate primarily to the predominantly passive and unstructured nature of the learner's interaction.

Both e-learning environments and the web typically offer relatively limited and closed forms of interaction for the learner. Because so much life-long learning is self-motivated, a greater degree of autonomy in interaction is desirable. The environment that best suits the life-long learner is then one that contains elements that are constructionist in spirit [6], and gives opportunities for learning by building. Since life-long learning also typically takes place in close association with concrete external activities, it is natural to consider using microworlds to provide a virtual environment within which exploratory learning can take place in context.

3. Model-building for life-long learning

The concept of life-long learning clearly invokes an evolution over time, both in respect of the learner's experience and of the context for learning. Such evolution is of course conceived in traditional environments for e-learning, but is typically constrained to follow prescribed paths. In such environments, the learner is exposed to new concepts, experiences and contexts in a systematic fashion, and the exposition is managed in such a way as to keep track of the learner's performance. But whereas the classroom learner's experience is shaped in an artificial closed environment, that of the life-long learner is not. A mature listener who takes up an instrument late in life may appreciate certain specialist elements of musical composition and interpretation better than a young teacher. A schoolboy experienced in IT may have a good practical grasp of principles of relational database design without being familiar with the formal notion of functional dependency. The life-long learner frequently combines a sketchy explicit understanding of fundamental principles with a depth of experience and a familiarity with practical contexts of application that seems incongruous and inappropriately advanced.

In these circumstances, the e-learning environment that is designed to suit the learning purpose best under stereotypical conditions is no longer necessarily effective. It may be appropriate to address topics in any order, to make opportunistic, serendipitous links, or to change the strategy mid-process in the light of

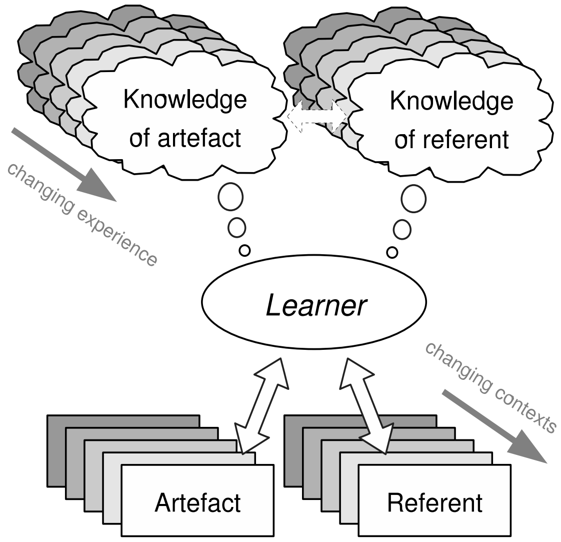

Figure 1. Learning through model-building

developments in the open world outside the classroom. Such issues can only be addressed to a limited degree by the preconceived design of an e-learning system. It is hard enough to develop adaptive systems that are selective and discriminative when the learning trajectory has been comprehensively monitored; it is impossible when the learner's engagement is casual and incidental to much broader interaction in the outside world. In the typically informal and unstructured setting of life-long learning, the onus of bridging the gap between standard textbook knowledge and procedures and their often disguised or distorted real-life counterparts then has to fall upon the learner.

Such 'soft' learning needs can be addressed by developing technology to support the learner in sense-making activities. In a life-long learning setting, this sense-making can take many forms. It may involve making a model of a situation drawn from the learner's working environment that can be used to gain a deeper understanding of what relationships and mechanisms are at work. Alternatively, it may involve a process of concretization: constructing a physical artefact to embody an abstract process whose practical relevance and application is obscure. As a prominent component of much life-long learning is the exposure and rationalisation of activities and concepts of which the learner already has implicit informal knowledge, the construction of models and artefacts cannot in general be based on a pre-existing theory. As in constructionism, the process of building can itself be a process of active learning, through which connections are made and relationships between different experiences come to be better understood.

The nature of the model-building activity that can meet the life-long learner's requirements is depicted in Figure 1. The term *artefact* is used to refer to the model that the learner builds in order to stress its physical experiential character. As discussed above, the artefact is built with some experience to be explored and better understood in mind. The experience to which the artefact itself refers may relate to a situation, to an abstract procedure, or to a phenomenon: to respect such generality, the neutral term *referent* has been adopted. The referent could be something physical, or, in the case of an artist, the referent could be an emotion or idea that their artefact will convey. The learner develops tacit knowledge of the artefact and referent through exploratory interaction motivated by establishing a close correspondence between experience of the artefact and experience of the referent. The layering in the diagram is used to convey the idea that the relationship between the artefact and its referent evolves dynamically. The context in which the artefact and referent are being experienced is constantly changing, and invokes a change in the implicit knowledge of the artefact. As is to be expected in the life-long learning setting, both the experience of the learner and the context for the exploratory interaction develop over time.

4. Illustrating EM for life-long learning

Traditional e-learning environments rely upon crafting the learning context through imposing specific patterns of interaction. This is a good strategy when learning activity can follow a preconceived plan. Such environments can be built by traditional programming, where construction is driven by identifying the required use-cases and optimising for these.

By contrast, the experienced life-long learner will typically bring an individual, possibly idiosyncratic, perspective to bear on issues to be learnt. To accommodate this, a learning artefact for life-long learning needs to be conceived in quite a different way from a conventional program. As discussed in more detail in previous papers [2], Empirical Modelling (EM) is an alternative approach to computer-based model-building that suits the constructivist vision of learning depicted in Figure 1. EM entails the development of *construals*: interactive artefacts that embody the learner's personal understanding of a situation or referent. Such construals are developed by imitating the relations between observables, dependencies and agent actions that are identified as characteristic of the referent. The process of identification and construction resembles that involved

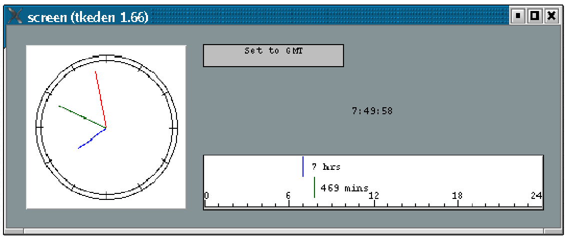

Figure 2. A variant of the clock model

in developing a spreadsheet, and leads to a network of observables (cf. spreadsheet cells) and dependencies (cf. relationships between cells) that are expressed in a family of definitions, or *definitive script*. The versatility of EM as a vehicle for learning is consistent with other findings relating to the application of spreadsheet principles in learning [1].

An extended example will serve to illustrate the principles of EM in relation to life-long learning. The theme of this example – that of learning about time and clocks – is too simple to be fully representative of the applications of EM to learning (cf. [8]), but highlights many of the essential characteristics.

As remarked above, the sense-making activity depicted in Figure 1 can reflect many different kinds of learning. Relevant topics might relate for instance to: being familiar with clock mechanisms; understanding the relationship between digital and analogue representations of time; appreciating how the analogue clock concretizes abstract relationships in modulo arithmetic; or knowing how to tell the time in different languages and in different time zones. In a life-long learning context, each learner will bring a different orientation and experience to these diverse perspectives on clocks and time. The process of construal that EM supports reflects this rich and potentially confusing combination of concerns. The various perspectives and their interrelationships are reflected in variants of what can be regarded as one model, as developed in different directions according to the learner's particular needs. An important feature of this model is that in principle it concurrently offers the same potential for redefinition and adaptation to all participants in the learning – whether model-builder, teacher or learner. In this way, it can serve in many different educational roles as a learning artefact – some aspects being developed autonomously by the learner, some supplied by an expert modeller, and some adapted and customised by a teacher.

The simplest form of sense-making model takes an analogue clock as its referent (cf. the left-hand side of Figure 2). The relevant observables in this context include the current local time, the time as shown on the clock, the radius of the clockface and locations of the marks around its rim, and the lengths, colours and positions of the hands. Relevant dependencies link the position of the hands to the time as shown on the clock, which in turn may depend on the current time in a variety of ways according to the status of the clock. For instance, the clock may be stopped, fast or slow, or refer to a distant time zone. To reflect the physical integrity of the clock, the positions of the marks on the rim and the lengths of the hands depend upon the radius of the clockface. In developing the EM construal, the geometric elements of a line-drawing to depict the clock can be specified (e.g.) as points, lines and circles whose attributes are linked by definitions to scalars and textual data that represent times, dimensions and other geometric attributes such as colours and linestyles. Full details of the definitive script together with notes on its development can be found in the EM archive [12] as `clockBeynon2001`.

The merits of the EM construal as a learning artefact relate to the open-ended interactions that it enables. Though the clock exhibits standard modes of interaction and behaviour, its observables, dependencies and the agency to which it is subject are all open to revision at the discretion of the learner – whether or not they respect the boundaries of commonsense. This is in keeping with the principle that the engineer learns most not just by observing the clock in normal operation, but by dismantling and rebuilding it, and the user learns most by interacting with the clock in exceptional contexts and exploratory ways.

By way of simple illustration, in the clock model as described above, the positions of the hour and minute hands are independently determined by the current time. In practice, the hands of a mechanical clock are linked so that you can move the minute hand and the hour hand moves at a slower (but proportionate) rate. The clock artefact can be adapted to exhibit this behaviour by introducing the dependency that links the position of the hour hand to that of the minute hand. Underlying the design of the analogue clock as an engineering product are simple principles to connect elapsed time in hours and minutes modulo the number of minutes in an hour and hours in a day. The abstract relationships between 'time as recorded by hours and minutes elapsed in a day' and 'time as displayed on digital and analogue clocks' are given concrete expression in the variant of the original clock model shown in Figure 2. This variant is derived simply by giving visual expression to scalar relationships that are already explicit in the original clock model.

By way of further illustration, the time as shown on the clock can be redefined in such a way as be totally

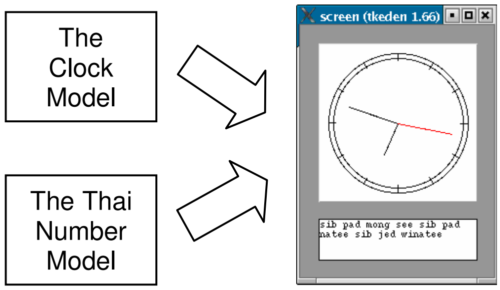

Figure 3. A blend of two models

independent of the current local time, or so as to reflect the time in another time zone. The significance of specifying the time difference between Japan and UK time as plus 9 hours, rather than minus 15 hours, or even plus 5 hours, exposes the physically constrained and socially constructed nature of world time. The focus on clocks and time in physical and cultural context is well-oriented to life-long learning, where contextual factors potentially both enrich and obstruct understanding. For instance, it is indicative of the imperfect and potentially confusing nature of learning to read clocks in a real-world setting that (e.g.) the hour hand may be misaligned so that it is not quite vertical at midday etc. It is easy to tweak definitions to imitate this condition, or to express more dire forms of mechanical failure, as when the minute hand comes loose and hangs vertically downwards.

The EM construals described above illustrate how Figure 1 applies both to the modelling of a concrete referent, and to the concretisation of abstract relationships. Because of the dynamic and provisional nature of the relation between artefact and referent in Figure 1, it is also possible to regard it as a framework within which two or more artefacts can be combined and can evolve into a new learning artefact. Previously, an EM artefact for learning about counting in different languages was built [9]. By placing this artefact in conjunction with the clock artefact, and adding new observables and dependencies it is relatively easy to derive an artefact for telling the time in different languages (as well as different time zones). Figure 3 depicts the artefact displaying the time in Japan whilst expressing the time in Thai.

5. Concluding remarks

This paper has focussed on introducing EM principles by studying a small example in detail. Taken as a whole, the variants of the clock model described above illustrate several features of EM that are well-oriented towards life-long learning. Wider applications of EM principles and further evidence of their potential for life-long learning can be found in [3].

Where current educational technologies are best oriented for well-planned and organised learning situations, learning in a real-world setting typically begins in some degree of chaos and confusion. EM principles and tools are still at an early stage of development, but show promise in supported learning activities that integrate educational modes, promote flexible opportunistic learning, and blend the concrete and the abstract across disciplines. These are qualities that can be most helpful in engaging the life-long learner.

6. References

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