Chapter XIX
A Changed Economy with Unchanged Universities?
A Contribution to the University of the Future

Maria Manuela Cunha
Polytechnic Institute of Cavado and Ave, Portugal

Goran D. Putnik
University of Minho, Portugal

ABSTRACT

Individualised open and distance learning at the university continuing education and post-graduate education levels is a central issue of today. The advanced information and communication technologies together with several applications offer new perspectives, such as the so-called virtual university. Simultaneously, to gain market share, several organisational arrangements are emerging in the virtual university field, like consortia arrangements and joint venture initiatives between and among institutions and organisations. The dynamically changing social and economical environment where we live claims for new approaches to virtual and flexible university continuing and post-graduate education, such as the concept of Agile/Virtual University proposed by the authors. However, the implementation of this concept (and of other similar concepts) does not rely just on basic information and communication infrastructure, neither on dispersedly developed applications. Although absolutely necessary as support, the added value comes from the higher-level functions to support individualised learning projects. The implementation of the Agile/Virtual University concept requires a framework and a specific supporting environment, a Market of Teaching Resources, which are discussed in the article.
INTRODUCTION

In the fast-changing and strongly competitive business environment we live, a confluence of factors such as (1) the economic globalisation and integration, (2) the impact of technological developments, (3) the growing demand for sustainable development and (4) the emerging work systems are having a strong impact on organisations, on society and on individuals.

Advances in information technologies (IT) are now one of the major driving forces of change. IT is an essential infrastructure for competitiveness of other economic sectors, and the basis for trade, provision of services, production, transport, education and entertainment (ACTS, 1998). IT is transforming organisations into global networked structures, with processes extended through continents, creating markets and systems not just global and distributed, but virtual, in a new perspective of a global, networked and knowledge-based economy.

The fast evolution of IT is creating a huge role of opportunities, and simultaneously of challenges to organizations and to society. Organisations of every stripe try to respond to the challenges by adapting their strategies and activities; that is, restructuring to align themselves to the new requirements of the changing economy, where every sector of society will systematically use IT. These technologies support concepts as distributed systems, computer supported cooperative work, telework, electronic commerce, electronic marketplaces, virtual manufacturing, concurrent engineering, some forms of distance education, and many others.

Distance education (Web-based) seems to be a contribution towards the democratisation of learning access in particular in the domain we are concerned with - the university continuing education and post-graduate education.

According to several authors, (Evans & Nation, 1996; Khakhar & Quirchmayr, 1999) the most relevant advances in distance education over the past three decades have been in the university sector, where Open Universities represent an attempt to establish fully integrated distance-teaching systems.

However, the new approaches to learning, such as flexible and distance learning, are still at an immature stage. Although some of these concepts have existed for several years, there is not yet a clear understanding of the way these approaches will evolve and become useful and common practices.

Another concern is that systems conceived to provide integrated standard off-the-shelf learning solutions are less efficient when compared with dedicated systems. Providers of units of learning, primitive or complex, can be integrated in completely individualised (customised/tailored) flexible Web-based networked learning projects, which in turn can be agilely and dynamically adjusted to either the performance of the providers or to the learner evolution or changing requirements. This corresponds to a new structure of learning for each individual (learner) while, at the same time, each provider (teacher) can specialise himself in focused units of learning, and get economies of scope by providing - with high quality - the same unit in several different learning projects. This concept requires an environment to cope with several concerns, such as assessment, accreditation, quality assurance, trust, and so forth, such as the Market of Teaching Resources here proposed, and must be mediated by a broker.

IT innovations are stimulating the growth of markets for educational services and the emergence of for-profit competitors, which could change the higher-education enterprise (Goldstein, 2000).

In this contribution, we introduce the Agile/Virtual University (A/V U) concept, as an integrated set of providers of units of learning that is integrated to respond to an individualised need. The product provided by the A/V U is an individualised learning project (a continuing training/education course). These providers can
be universities, university teachers and individuals (independent teachers), organised and managed by either a higher-education enterprise or a university itself, in a specific environment proposed by the authors as a Market of Teaching Resources.

The paper discusses the challenges to the university of the future, introducing the concepts of individualised learning project and Agile/Virtual University in the second section, and the new roles of the teacher and of the individual in the third section. In the fourth section it is introduced a framework conceived to implement the A/V U model and, in the fifth section, it is introduced the Market of Teaching Resources as an enabler of A/V U. The sixth section concludes the article.

BACKGROUND: ENABLING TECHNOLOGIES, FRAMEWORKS AND APPLICATIONS

Internet enabled and enhanced communication, publishing and collaboration for individuals and organisations over a worldwide computer network. Initially, restrictions in bandwidth, storage capacity and processor power limited interactions over the Internet to text-based applications and technologies (Looms & Christensen, 2002). Today interactive applications and media-rich content are possible due to several infrastructure and standards, such as the XML (the W3C Extensible Markup Language Standard) for document structure, the SOAP (the W3C Simple Object Application Protocol) as a specification for computer communication and MPEG (the Motion Picture Experts Group standards) for video compression and delivery, which allow one to package, delivery and present learning contents in new ways. But a new generation of needs emerged regarding the specificities of e-learning, which claimed for specific standards, frameworks and approaches.

In this section we introduce some concepts and review the main developments and contributions regarding standardisation in the e-learning domain.

The Concept of E-Learning Objects

Several different definitions of e-learning objects can be found in literature, and other terms are used seemingly interchangeable in place of e-learning objects. In this paper, Wiley’s definition is adopted. Other terms proposed by Cisco (2001) are educational objects, content objects, and training components. According to Wiley, a learning object is a “reusable digital resource to support technology-supported learning” (2000).

Cisco defines a learning object as a “(…) granular and reusable chunk of information that is media independent” (2001, p.5). Learning objects allow instructional designers to build small or elementary instructional components that can be reused in different learning contexts, deliverable over the Internet. They represent reusable units of learning content that can be consumed or studied within a single learning session or a predefined period of time, organised in larger units such as classes or courses, if desired. At CEDAR (Centre for Economic Development and Applied Research), an e-learning object is defined as a small piece of text, visual, audio, video, interactive component, and so forth, that is tagged, and stored in a database (Muzio, Heins, & Mundell, 2002, p.24).

The first generation of e-learning systems focused essentially on the management and measurement of training process, delivering inflexible courses, adding little or no value to the learning process (Ismail, 2002). According to the author, with whom we agree, these e-learning systems (learning management systems) were not designed to help organisations to collect, organise, manage, maintain and reuse instructional content.

In their current situation, learning technology standards do not support interactive learning objects properly, as widely accepted (Hanish & Straber, 2003). Today, it is recognised the need to move towards producing database-driven reusable learning objects, and that they should
conform to relevant standards, some of them to-be-developed.

**The Virtual University Concept**

In recent years the definition and application of open and distance learning has been evolving in parallel with the arrival of newer and intelligent technologies (Commonwealth of Learning, 2003). According to a Commonwealth of Learning evaluation report on virtual education (Farrell, 1999), the label virtual is widely and indiscriminately used and it is frequently used interchangeably with other labels such as open and distance learning, distributed learning, networked learning, Web-based learning, and computer learning. Another Commonwealth report (Farrell, 2001), clarifies that open and distance learning embraces any or all of the concepts and practices of open learning, flexible learning, distance education, online learning and e-learning, and virtual education.

To gain market share in the lifelong learning market, several organisational arrangements are emerging in the university virtual learning, and are the result of partnerships between institutions or businesses and institutions, joint venture initiatives between and among institutions and organisations, consortia arrangements, and so forth. Examples of emerging models include: for-profit university initiatives (Dirr, 2001), consortia and alliances of universities or of high schools (Dirr, 2001), the open school, broker-type organisations (Farrell, 1999), and corporate-university joint venture (American Federation of Teachers, 2001). Simultaneously, complementary institutions that do not provide instruction directly emerge in the virtual university field. Examples include institutions authorised to provide services as quality assurance, award credentials, learning assessment, learning records and so forth, and broker-type organisations, designed to broker programmes from individuals and institutional providers.

The definition proposed by the Commonwealth of Learning for the concept of virtual education institution (Farrell, 2001), consists of an institution involved as provider of learning opportunities to students, using information and communication technology to deliver its programmes and courses and provide tuition support, and is the result of alliances/partnerships to facilitate teaching and learning to occur without itself being involved as a direct provider of instruction. We accept this definition and use it as a basis to the proposal of the new concept of Agile/Virtual University.

There are still few examples of virtual educational institutions, namely of virtual universities. Besides several valuable examples like the Michigan Virtual University (http://www.mivu.org/) and the University of Phoenix (http://www.phoenix.edu/), we still can say that most of the developments towards virtual universities are experimental, and many times still do not address the needs of their potential clients. The market for virtual university learning is being fragmented (as the markets for all sorts of goods and services), with niche learners, each time more demanding, rather than mass clientele, and this market is becoming more and more competitive even in a world-wide scale, with global providers acting through strategic partnerships.

**Standardisation and Interoperability Efforts in the E-Learning Domain**

E-learning standardisation is currently a vital concern and a continuously evolving process that, according to several authors (Anido et al, 2003) will last for years until a clear and generally accepted set of standards is developed.

From the perspective of integrability there are significant efforts towards standardisation at two levels: (1) Specification of data models and information models involved (specification of the format, syntax, semantics of data concerning learners, course structures, educational contents, etc., to be transferred among platforms); (2) Specification of architectures, software components
and interfaces (for managing the information models, i.e., for managing learning objects in online environments) (Anido et al., 2003).

Several contributors towards the development of standards for education-related systems can be enumerated, such as IEEE’s Learning Technology Standardisation Committee (LTSC), The National Institute of Standards and Technology (NIST), the IMS Global Learning Consortium, Inc. (Open Specifications for Interoperable Learning Technology) (IMS, 2004d), the Aviation Industry CBT Committee (AICC, http://www.aicc.org), the US Department of Defence’s initiative Advanced Distributed Learning (ADL, http://www.adlnet.org).

Several projects should also be mentioned: the Alliance of Remote Instructional Authoring and Distribution Networks for Europe (Ariadne, 2004), PROmoting Multimedia Access to Education and Training in EUropean Society (PROMETEUS), Gateway to Educational Materials (GEM), Getting Educational Systems Talking Across Leading Edge Technologies (GESTALT), and the Information Society Standardisation System are some of the most relevant. Specifications that have already been released by IMS include: IMS Digital Repository Interoperability model (first draft approved in August 2002) (IMS, 2003b), Content Packaging (IMS, 2003a), Learner Information Packaging (IMS, 2003d), Metadata (in May, 2004) (IMS, 2004a) and Question and Test Interoperability (last public draft in June, 2004) (IMS, 2003e, 2004b, 2004c) and Learning Design (IMS, 2003c) -- this last can be considered as an integrative layer to some of the above-mentioned specifications. IMS project groups are in the process of improving specifications for competency, accessibility, learning design and digital repositories.

SCORM (Sharable Content Object Reference Model) project, an ADL (Advanced Distributed Learning) initiative based on the CMI specification of the Aviation Industry CBT Committee, is a model for content exchange between different learning management systems. The purpose of SCORM is to achieve accessibility, interoperability, durability and reusability within SCORM compatible content (ADL, 2002).

Another field that is waiting for developments is the educational metadata one. Metadata (data about data) provides descriptions, properties, information about objects (in our case, learning objects) to characterise them in order to allow its manipulation and management. Many efforts can be listed, including almost the entire above list of projects and initiatives, but we are still waiting for generally accepted recommendations and standards (Dodds, 2001). LOM, the IEEE Learning Object Metadata (IEEE 1484.12.1—2002) is a major contribution that specifies the syntax and semantics of learning object metadata (Hodgins, 2002).

The ability to search repositories is fundamental to provide access and delivery content from distributed repositories. The Open Archive Initiative (OAI) is a technical and organisational metadata framework designed to facilitate discovery of content in distributed repositories, specially directed to peer-reviewed information (scientific papers) (Lagoze & Van de Somple, 2002).

The growing interest over Web services is based on the potential for a combination of XML, the Web, the SOAP and WSDL specification and some to-be-defined protocols. Web services are designed as standard reference architecture to promote integrability.

**Brokerage for Educational Systems**

Efficient searching and selection of educational content is a key feature of distributed Web-based educational systems. Traditional technology (search engines and directories) could be used to search the Web for educational content; however, it is easy to conclude that these do not cope with our requirements.
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The role of third party intermediaries, linking different parts of a value chain, has been covered extensively by researchers in economics and business, and the question seems to be whether the future will hold a place for intermediaries, given that new technologies facilitate direct links between market players, such as manufacturers and end-consumers of products, or businesses and their suppliers.

In the e-learning environment, brokerage will support the match between offer and demand of learning objects. The GESTALT project proposes a brokerage service for educational resources, named Resource Discovery Service, within a pool of registered providers of educational contents (GESTALT, 2003). In Anido et al. (2003) it is described a proposal for a Domain CORBA facility for educational brokerage that defines the software services needed in an intermediation framework for learning objects, using the OMG’s Interface Definition Language (IDL). IDL is not tied to any specific environment or platform.

Frameworks and Applications Under Development

It is a generalised concern the provision/delivery of effective and efficient access to information/learning contents/learning objects, communication teacher/facilitator—learner, provides also improved learning opportunities.

In Ismail (2002) it is proposed an e-learning systems framework, specifying a learning system's architecture for pedagogical development and systems integration, based on the Learning Technologies Systems Architecture (Architecture and Reference Model Working Group, IEEE) developed by IEEE and other standards organisations such as Aviation Industry CBT Committee, IMS Global Learning Consortium and the Advanced Distributed Learning Network. This framework allows organisations to envision and craft their e-learning systems while maintaining interoperability with third party applications and content (Ismail, 2002).

In Ong & Hawryszkiewycz (2003), the authors propose a framework for integrating personalisation and collaboration in a virtual learning environment, in a learner-centric approach, where learners are expected to actively engage in the learning process to construct their own learning and instructors play the role of facilitators, guiding the learning process.

Lin et al. (2001) propose a framework for designing and developing agent-based online learning systems, integrating software agents and learning objects.

The contributions of Anido et al. (2002) address the interoperability problem due to the proliferation of online learning systems, proposing CORBA as the technological supporting infrastructure.

Academic institutions such as the University of Calgary [CAREO System (CAREO, 2002)] or the Technical University of British Columbia [POOL Project (Richards & Hatala, 2001)] have developed and deployed Distributed Learning Objects Repository Networks (DLORN) using peer-to-peer protocols.

The peer-to-peer (p2p) model is not new and despite its problems in the beginning of its use in the academia — generalized copyright violation and uncontrolled usage of the computational resources and the institution bandwidth, which are used in entertainment and non productive activities (Vilano, 2005) - a strong interest and curiosity in academic environments for such applications is rising (Schoder & Fischbach, 2003). Projects like Edutella (Nejdl, 2002), Comtella (Vassileva, 2004) and especially Lionshare (LionShare Team, 2004), and developments like Elena (Kieslinger & Simon, 2004; Rivera et al., 2004), bring p2p to the arena of large scale sharing of resources in the academic world.
A NEW CONTEXT AND NEW CONCEPTS

The convergence of information technology developments, together with instructional and pedagogical developments, is creating opportunities for new paradigms of learning and teaching. New concepts of post-graduate university education and of university continuing education will emerge, where new roles for individuals and institutions will be available, and where new requirements will constringe.

According to Hicks, Reid, & George (2001), universities are asked to provide for a larger and more diverse cross-section of the population, to cater for emerging patterns on educational involvement in order to facilitate lifelong learning and to include technology-based practices.

In this section, we discuss a new concept of networked virtual Web-based learning and teaching environment, where universities or providers make their units of learning available to learners in a market of teaching resources (i.e., mediated by a third party), under the format of individualised learning projects.

The Agile/Virtual University and Individualised Learning Projects

The emergence of virtual institutions is directly linked to the development of, and access to, information technology and communications infrastructure, and is contributing to overcome the socio-economic and geographical disadvantages in acquiring skills and knowledge.

Many people believe that IT will introduce structural changes to the universities, both in the organisational domain and in the research and learning domains. While university administrative activities have been transformed by IT (e.g., student and faculty communications), other higher education functions have remained more or less unchanged, like teaching for example, which in many cases still continues to follow a classroom-centred, seat-based paradigm (National Research Council, 2002). This report by the National Research Council warns academe against “complacency in the fast-paced technological developments from virtual universities” (Kiernan, 2002).

As in earlier periods of change, the university will have to adapt itself to this changing economy, while protecting its most important values and traditions, such as academic freedom, a rational spirit of inquiry and liberal learning (National Research Council, 2002). In this changing economy, adaptation to change means to identify challenges and opportunities, and to reshape roles and activities, in order to align the university missions with the new requirements of society. Scholarly communities will shift from physical campus to virtual and globally distributed and networked structures.

One of the most widely discussed areas in recent business literature is that of organisational network structures as the basic principle to achieve flexibility and responsiveness in a highly complex environment (Bradley, Hausman, & Nolan, 1993; Byrne, 1993; Davidow & Malone, 1992; Handy, 1995; Miles & Snow, 1986). If, in the business domain, flexibility and responsiveness are the main competitiveness requirements to strategically align business with a more global, networked and demanding market, we are convinced that the same applies in the services domain, specifically in the domain of university education.

We agree that universities should strive to become learning organisations, much along with the well-known concept of Senge (1990), self-examining and self-improving the services; however, besides the recognised need to shift, the university of the future will not stand alone! It will consist on an agile network or partnership of providers of teaching units, configured in learning projects, designed and redesigned to dynamically respond to the needs of each individual.
But the strength of the university of the future will be in the fast response, high quality, dynamics/agility and customisation, to closely meet the learner’s needs and expectations, which are traduced in an Individualised Learning Project.

In our understanding, the concept of virtual university as presented in the literature and as we have introduced in the second section does not respond to the requirement of dynamics that we want to address. We understand the university of the future as a dynamically changing structure that works as a university. The university of the future is the Agile/Virtual University.

The A/V U concept is defended by the authors as an agile and virtual entity, integrated from independent providers of learning units (in principle university teachers, but also other independent teachers), existing solely to dynamically respond to a learning opportunity or need, traduced by an individualised learning project. After the conclusion of that learning project, the A/V U dissolves itself. During its lifetime, the A/V U can be subject of reconfiguration (changing or adapting its physical structure) in order to keep aligned with the learning project. Reconfigurability dynamics is a main requirement of this model, in order to be closely aligned with the learner’s needs and expectancies. An A/V U is expected to have integration and reconfiguration capability in useful time.

This way, a learning project, viewed as an integrated set of units of learning designed to meet learner requirements, can show its maximum efficiency and effectiveness.

A/V U reconfiguration implies the search and selection of new providers and can be the result of unpredictable changes in the environment (learner) or as a requirement of quality and competitiveness improvement, or even be due to un-accomplishment of responsibilities of a given provider. An A/V U can have as many instantiations (physical configurations) as required (reconfigurability) in order to align the Individualised Learning Project with the learner requirements.

Two main requirements are identified in the implementation of the A/V U model: (1) permanent alignment with user (or learner) needs and (2) reconfigurability dynamics. In order to respond to these requirements, the implementation of the A/V U model requires an environment covering the whole process, from the design of the Individualised Learning Project until the creation and reconfiguration of the A/V U responding to the project, assuring trust, accreditation, efficiency, quality, assessment, and so forth.

The concept of a Market of Teaching Resources consists of an electronically delivered intermediation service (with different degrees of automation), mediating offer and demand of teaching resources (or units of learning) to dynamically integrate in an A/V U and “brokers” (consultants, knowledge support). In this “virtual” environment, offer corresponds to teaching providers (providers of units of learning) that make their skills and knowledge available, as potential servers/partners for A/V U integration, and demand corresponds to learner, the individual looking for an individualised learning project to satisfy his needs. The Market of Teaching Resources intends to provide participants (learners/teachers) with access to a larger pool of learning/teaching opportunities (both offer and demand sides).

**Teachers, Learners, Brokers and ...**

**A Market of Teaching Resources**

A new entrant in the emerging university education market is the teaching provider (who can be a university teacher or a certified trainer/teacher), motivated to create learning opportunities for anyone who is interested.

Specialisation is becoming a mark to those new teachers that need to make their skills and knowledge available to a global market, to integrate strategic and dynamically reconfigurable partnerships—A/V Us -- according to individualised learning projects. These teachers can be reached through institutions providing market
access to teaching units, such as the Market of Teaching Resources.

The several providers of units of learning are subscribed to the Market, and form a graph where links between units of learning represent all the identified meaningful/possible combinations of units of learning in Learning Projects (Figure 1). An A/V U instance represents a physical structure of a set of integrated teaching providers, and reconfigurability along a learning project lifetime corresponds to the changing physical structures, as represented in Figure 2.

In the emerging context of learner pulls, versus market push, we assist to a shift from “knowledge providers to knowledge seekers” (Porter, 2000). The learner commands the process of course delivery, in such a way that a single university or educational institution could not answer. The proposed A/V U model empowers the individual/learner.

The agility and virtuality of this model is assured by the existence of a Market of Teaching Resources and by a human broker.

The presence of the broker in the Market of Teaching Resources is justified with the answer to questions such as: how does the learner locate the teachers; find the units of learning that fit its needs or draw an individualised learning project. Brokers are tailors that use the Market of Teaching Resources to design Individualised Learning Projects and to integrate/reconfigure an A/V U that is able to provide that project.

**New Challenges towards the Agile/Virtual University Model**

It is to recognise that the development of this new virtual educational models brings in change
forces in several domains: trust, quality and curriculum relevance to labour market needs, are some of the main requirements for the success of the A/V U model.

Specific regulations, legislation, accreditation, recognition of degrees and curricula, consumer protection, and cultural sensitivity are urgent concerns to promote, in order to allow this step further towards the development of liberalised agile and virtual learning concepts and the materialization of a new sort of organisational supporting environments (of which the proposed Market of Teaching Resources is an example). It would be out of our scope to highlight all of them, but some challenges associated to the emergence of these learning concepts involve:

- Certification of providers of units of learning, in a world-wide basis;
- Recognition and wide acceptance on the definition of units of learning, content, duration, objectives, supporting learning materials, and so forth. Recognition of units of learning between different institutions, by the attribution of units of credit and possibility of transfer, and so forth;
- Accreditation of brokers and all sorts of third parties intermediating offer and demand;
- Accreditation of institutions like the Market of Teaching Resources;
- Assessment and quality assurance of units of learning and of learning materials of support;
- Assessment of skills acquired by the individuals/learners;
- Maintenance of a learner profile, comprising goals, learning history (learning units studied or successfully completed), learning performance and preferences;
- Standardised design processes to support the definition of individualised learning projects.

Besides the legal aspects and the supporting legislation that this model would require, the Market of Teaching Resources should offer an environment responsible by assuring trust, assuring the implementation of rules and laws, quality assurance, counselling and management of the learning path of the individual, assuring the interface with the providers of teaching committing them to accomplishing the contracted roles, and so forth.

THE AGILE/VIRTUAL UNIVERSITY FRAMEWORK

The implementation of the A/V U model and its requirements requires a framework covering all processes in a learning project. The two basic properties, implicit in the designation A/V U, are virtuality and agility. Together with integrability and distributivity we have the four basic properties of the A/V U model.

The framework proposes that the A/V U model requires an enabling environment to cope with the intrinsic requirements of the model (the Market of Teaching Resources) and the Broker, acting through the Market, as the enabler for agility and virtuality. The Market of Teaching Resources together with the Broker offers the support to the A/V U model.

In this section, we discuss the meaning of these four properties in the A/V U model and how are they implemented. But let us first introduce briefly the concept of hierarchical system, a basic concept to understand our framework.

A Hierarchical System Model

The A/V U framework is based on a hierarchical system model as a global view of a learning project. The underlying formalisation is the theory of hierarchical multilevel systems by Mesarovic, Macko, & Takahara (1970). In hierarchical multi-level systems, a system S is specified as:
S: $X \rightarrow Y$

where $X$ is the set of outside *stimuli* and $Y$ is the set of responses. Both $X$ and $Y$ are representable as Cartesian products, that is, $X$ and $Y$ are assumed as a families of sets such that:

$$X = X_1 \times \ldots \times X_n$$

and

$$Y = Y_1 \times \ldots \times Y_n$$

representing the ability to partition the input *stimuli* and responses onto components.

Each pair of $(X_i, Y_i), 1 \leq i \leq n,$ is assigned to a particular level of a system $S_i$, represented as a mapping, as in Figure 3. $C_i$ is the result of level $S_{i+1}$ and passed to level $S_i$, while $W_i$ is the result of level $S_{i-1}$ and returned to level $S_i$, until we reach level 1.

**Basic Properties of the Agile/Virtual University Model**

The properties of the Agile/Virtual University model include: integrability, distributivity, agility and virtuality, which are introduced in this section.

**Integrability**

One of the most important requirements for the A/V U is the capability for efficient access to heterogeneous candidate teaching resources and their efficient integration in the A/V U. By “heterogeneous” teaching resources we mean that under the technological perspective, their supporting systems (applications and platforms) may work/operate internally in their own specific, proprietary language, that is, they may not conform to the same standard(s). Portability and interoperability among heterogeneous systems, as well as extendibility, reconfigurability, and longevity, are characteristics of the so-called *open system architecture*.

Integration is primarily the task of improving interactions among the system’s components using computer-based technologies with the following goals (Vernadat, 1996):

1. To *hide underlying heterogeneity and distribution* of functions, data, knowledge and functional entities to business applications and users, therefore ensuring portability;
2. To *facilitate information exchange and/or sharing* among applications, and
3. To *provide an open environment*, that is, an interoperable “plug and play” environment in which new components can be easily added or connected, updated or removed, for integrated enterprise operations.

Although the definition of distributed system refers the computer application domain (hardware and software), the same problems occur for components and processes integration, requiring some integration mechanism for the distributed systems. In this framework the integration mechanism assured by an “Integration Mechanism” (IM), represented in Figure 4, where *Control level i* corresponds to the learner and *Control level i+1* corresponds to the teaching provider.
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Figure 4. Elementary structure for an integrated and open hierarchical multilevel system control

The integration mechanism functions\(^7\) represent the required interface or translation functions between control levels and resources management levels, to assure integrability between the participants. The environment supporting the A/V U model (such as a Market of Teaching Resources) must assure integrability between the participants (teachers, learners and agents of agility and of virtuality), as represented in Figure 5. At this moment, this property is dependent of the developments in the domain of standardisation already mentioned in the second section.

Distributivity

In the context of the A/V U framework, the distributivity concerns the geographical dispersion of teaching providers (see Figure 1). It is important to consider spatial distribution of the A/V U components, because the A/V U requirement for reconfigurability, as a part of flexibility, implies the search of new teaching resources, to be allocated to the task to be performed, in order to satisfy new or changing circumstances. To obtain the best combinations of resources, it is desirable that as many as possible teaching resources providers concur to the integration of the A/V U. This requisite implies that the candidate providers are globally distributed and inter-connected using information and communication technologies (ICT), to enable the negotiation capability, the integration of the A/V U and the delivery of the contracted units of learning in an efficient, effective and real-time way. ICT enables the efficient access to remote providers distributed geographically, all over the world (see Figure 6).

We are not concerned with the implementation of the distributivity characteristic, as this is assured by the ICT infrastructure. The definition presented is oriented to a spatial distribution of the A/V U elements and not to distributed management or distributed software applications. A distributed structure does not imply a virtual structure. We may say that distributed structures are an intermediate step on the development and implementation of the virtual structures concept.

Figure 5. Integration mechanisms between levels of the A/V U framework

Figure 6. Elementary structure for a distributed hierarchical multilevel system control
Agility

The competitive foundations of agile manufacturing or enterprise are continuous change, rapid response, quality improvement, social responsibility and total customer focus (Kidd, 1994). An agile company is one capable of operating profitably in a competitive environment of continually and unpredictable changing customer opportunities (Goldman, Nagel, & Preiss, 1995). Agility is the capability for fast adaptability or fast reconfigurability in order to respond rapidly to the market (or customer demand) changes. We consider the same meaning for these concepts, in the context of the A/V U model.

As the A/V U implies interactions between various independent teaching providers, it will be required to control and manage inter-provider organisational configuration. It is essential to be able to define domains of responsibility for configuration management, which reflect organisational policy and permit limited configuration management facilities to be offered, or to be contracted. A/V U agility must be carried on by some “organisation configuration manager.”

Figure 7. Elementary structure for an agile hierarchical multilevel system control

Figure 8. Agility in the A/V U model - operation scheme

The “organisation configuration management,” that is the agility function, is presented by the “Resource Management_1” level, and implemented by the broker (Figure 7 and Figure 8). Control level $i$ corresponds to the learner and control level $i+2$ to the providers of teaching units (A/V U participants); control level $i+1$ corresponds to the broker.
Figure 8 represents a scheme of the A/V U elementary structure operation. It is important to notice that the structure proposed provides the reconfigurability between two units of learning (by the unit of learning it is meant a set of processes carried on by a single provider and without interruption). When the unit is concluded, the broker can reconsider the organisation structure and act with the objective to adapt it (to reconfigure it). The broker is the principal agent of agility. Reconfigurability between two units can also be a request of the learner: reconfigurability can also be the result of a demand of the learner to change its learning project, and the Market, together with the broker, can agilely respond to that demand.

Virtuality

In the specific organisational structure between A/V U participants (teachers) and brokers, the learner is not aware of the mechanisms used to communicate with, activate, or store the server object, let objects discover each other at run time and invoke each other’s services.

Virtuality makes possible the transition from one A/V U physical structure (instance) to another in a way that the learner is not affected by the system reconfiguration nor aware of the reconfiguration - the underlying service structure and reconfiguration process are hidden.

To implement the “virtuality” in the A/V U it is proposed the introduction of some organisation configuration manager, that is, the broker, similarly as for the concept of agility. The organisation configuration management, that is, the function that provides virtuality, is presented through the Resource Management_2, implemented by the broker (Figure 9 and Figure 10).

In Figure 10 it is presented a scheme of the A/V U elementary structure operation. It is important to notice that the proposed model hides the physical structure from the learner; that is, the elements of one instance of the A/V U are not seen by the learner. When the broker reconfigures the A/V U, it is without intervention of the learner.

The underlying physical structure of the A/V U can be hidden to the learner. The broker must provide the transition from one physical structure to another in a way that the learner cannot be affected by the system reconfiguration.

The main motivation for the application of the three-level hierarchy model is the learner's
lack of time or of knowledge to supervise the teacher/provider, or to monitor its own learning project. But even in the case the learner has both the required time and knowledge, in order to identify a reconfiguration need (substitution of any provider) it is necessary to perform reconfiguration in parallel\(^8\). In the agility scheme, as previously defined, the delivery of the unit of learning and the A/V U reconfiguration are still performed in a sequence.

A MARKET OF TEACHING RESOURCES FOR INDIVIDUALIZED GLOBAL NETWORKED WEB-BASED LEARNING

The implementation of the proposed concept of A/V U requires the ability of (1) flexible and almost instantaneous access to the potential teaching resources providers to integrate in a learning project, negotiation process between them, selection of the optimal combination and its integration; (2) design, negotiation, monitoring, management and performance evaluation functions independently from the physical barrier of space; and (3) minimisation of the reconfiguration and integration time.

The learner must have a correct idea of its needs and requirements, so that the Market can traduce them into a learning project. This learning project must be clear and consistent, as it will be the basis to the task performed by the Market of searching, selecting and integrating the teaching resources providers in a virtual university able to respond to the learner requirements.

The service provided by the Market is supported by: (1) a knowledge base of teaching resources and results of the integration of resources in previous projects, (2) a normalised representation of information, (3) computer aided tools and algorithms, (4) brokers and (5) a regulation, that is, management of negotiation and integration processes. It is able to offer (1) knowledge for resources search and selection and its integration in a virtual university, (2) specific functions of operation management of the virtual university, and (3) contracts and formalising procedures to assure the accomplishment of commitments, responsibility, trust and deontological aspects.

Market of Teaching Resources: The Process Structure

The overall functioning of the Market of Teaching Resources is represented in Figure 11, using an IDEF0\(^9\) diagram. It consists of the creation and management of the Market of Teaching Resources as the environment to support Virtual University Design and Integration and Virtual University Operation, offering technical and procedural support for the activities of identifying potential teachers, qualifying teaching resources providers and integrating the Virtual University, as well as coordination and performance evaluation mechanisms.

- **Process A.1.—Market of Teaching Resources Creation and Operation**: This process corresponds to the creation and operation (management/ maintenance) of the environment proposed, from the technological aspects—such as the creation of databases and development of software tools, implementation of communication systems—up to the definition and permanent adaptation and updating of the managerial aspects, such as regulation and rules, criteria for selection, management and brokerage procedures, organisation of the Market, commitments definition, evaluation, and so forth, including the performance of the Market itself in order to improve the Market organisation.

- **Process A.2.—Virtual University Design and Integration**: This process consists of three main activities—Virtual University
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Figure 11. IDEF0 representation of the global process for the Market of Teaching Resources Creation and for Virtual University Design, Integration and Operation

Request, Teaching Resources Selection and Virtual University Integration. Virtual University Request consists of treating the request presented by learner (or client), and involves the design of the learning project configuration/reconfiguration and the specification for teaching resources selection and negotiation (Virtual University Project) that matches the learner requirements. Teaching Resources Selection involves the search for the eligible resources providers to participate in the Virtual University to be created/reconfigured, negotiation among them and then selection of the “best” combination of resources to be integrated in the structure. There-design or reconfiguration of a Virtual University, implying the substitution/integration of new resources is considered also in this process, as well as the dissolution of the Virtual University. Integration consists on formalising the structure (contractualisation) and on the establishment of procedures regarding the integration of the participants and the implementation of management and evaluation techniques. Process A.2. is detailed in Figure 3.

- **Process A.3.—Virtual University Operation**: The service provided by the Market controls the operation of the integrated Virtual University, tracking the performance of each resource provider, and restructuring the structure (reconfiguring the Virtual University) whenever necessary along the learning project lifetime. The operation results are of interest to keep actualised historical information concerning the performance of the resources providers, to be taken into consideration in future selection processes, and to adjust the management and monitoring procedures.
Virtual University Design and Integration

In this section we focus on the process of Virtual University Design and Integration (Process A.2.), detailed in Figure 12, discussing the alignment between (1) the client of the Market of Teaching Resources, (2) the entities involved in a Virtual University integration, that is, candidate providers and (3) learning projects.

To keep the dynamics of the Virtual University model, the optimal combination of resources to integrate should be obtained almost in real-time. The complexity of the resources selection in general means that a compromised domain size (as a base for the solution space construction) should be used for each resource search. For each search, the Market of Teaching Resources proposes a Focused Domain (composed by Focused Markets), reasonably dimensioned, to allow a good match at a limited time.

The first step of the Design and Integration process is the design of the Virtual University, that is, the Learning Project, as a result of a Learner Request for a Learning Project (Process A.2.1.), which means (1) the translation of the specification parameters provided by the client and traducing its needs (input flow “Learning Requirements”) into Normalised Teaching Resources Selection Requirements and (2) the translation of the specific learning constraints defined by the client that will determine the process for search of potential resources providers (input flow “Learning Constraints/Negotiation Parameters”) into Normalised Negotiation Parameters.

The Teaching Resources Selection process (Process A.2.2.) takes place in three phases: (1) eligible resources identification, (2) negotiation, that is, identification of candidate resources and (3) final selection or identification of selected resources for integration. The process corresponds to visiting all the elements proposed by the focused domain, in order to identify negotiation parameters (availability, time to respond to the demand, or time to offer the resource, and costs), and perform an optimal search algorithm considering the client’s negotiation parameters and subjected to the client project constraints (time to complete the product, cost, etc.).

Virtual University Integration (Process A.2.3.) consists on the formalisation of the structure that

Figure 12. IDEF0 representation of Process A.2.—Virtual University Design and Integration
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will provide teaching: establishing procedures, normalising processes, interoperability, responsibilities and commitments. While selection means to check availability and to find the best resources that meet the requirements, integration means effective allocation and formalisation of the partnership.

CONCLUSION

We highlighted the emergency to reshape the virtual university continuing education concepts. This article discusses the necessary evolution of continuing university education to face the changing economy and introduces a framework for a new concept of university virtual education—the Agile/Virtual University model. It is also included a high level specification of an environment to cope with A/V U called a Market of Teaching Resources.

The model traduces a challenge to the traditional way we conceive the university structural organisation and the delivery of services to the society; the concept of the university of the future brings in serious implications and urgent concerns and, as such, must be faced with determination.

The structure of the university of the future can be founded upon knowledge and concepts developed and under development in other domains, like the domain of the virtual enterprises, in order to accelerate the implementation of the university of the future and to take profit from concepts and advances already achieved and validated or under validation. The model introduced in this paper is part of a wider research project under development at the University of Minho, addressing the Agile/Virtual Enterprises organisational model, whose validation the authors intend to undertake also in the university continuing education field.

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ENDNOTES

1 Complex units of learning are understood as meaningful combinations of primitive units. The concept of e-learning object (introduced in the second section) corresponds to the concept of primitive unit of learning.

2 Documents available at IMS (http://www.imsglobal.org/specifications).

3 OMG(Object Management Group) is an open membership, not-for-profit consortium that produces and maintains computer industry specifications for interoperability.

4 To the authors, a unit of learning can be an e-learning object or a combination of e-learning objects, constituting a chapter or a module in a subject or a course.

5 This is not a new concern in a “learning-on-demand” environment. A consortium of around 600 institutions has been joining efforts towards the identification of standards since year 2000 (Porter, 2000).

6 This framework is based on the BM Virtual Enterprise Architecture Reference Model (BM_VEARM), conceived by Putnik (Putnik, 2000; Putnik, Cunha, Sousa, & Ávila, 2005). The BM_VEARM is a reference model for enabling the highest organis-
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ational/structural reconfigurability dynamics and operational inter-enterprise dynamics of Virtual Enterprises. As the A/V U concept shares some of the properties of the Virtual Enterprise organisational model, the BM_VEARM is adapted to suit the specific requirements of the A/V U model.

The integration mechanism functions (represented in Figure 5) are not levels of the model.

This is the main principle of the concurrent or simultaneous engineering model.

9 IDEF stands for ICAM DEFinition methodology (ICAM—Integrated Computer-Aided Manufacturing). IDEF diagrams illustrate the structural relations between two processes and the entities present in the system. The processes (represented as boxes) transform the inputs into outputs (respectively the left and the right arrows of a process), using the mechanisms for the transformation (the bottom arrows of a process) and constrained by control information or conditions under which the transformation occurs (the top arrows).

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