Open Educational Resources: What they are and why do they matter

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Introduction

Assume a world where teachers and learners have free access to high-quality educational resources, independent of their location. Assume further that many of these resources are collaborative produced, and localized and adjusted for the learner's specific needs and context. Assume that the cost of producing and maintaining these resources would be distributed across a large number of actors and countries. Assume further that the costs were declining rapidly and, for practical purposes, could be considered to be negligible.

Such a world exists, today, in a laboratory scale. In the next several years, it will become possible in a scale that will radically change the ways in which we learn and create knowledge.

One element in this change is open access to educational resources. In a recent article, Charles M. Vest, President Emeritus of the Massachusetts Institute of Technology, summarized some of his experiences:

> "My view is that in the open-access movement, we are seeing the early emergence of a meta-university—a transcendent, accessible, empowering, dynamic, communally constructed framework of open materials and platforms on which much of higher education worldwide can be constructed or enhanced. The Internet and the Web will provide the communication infrastructure, and the open-access movement and its derivatives will provide much of the knowledge and information infrastructure."[1]

This report describes ongoing initiatives and underlying concepts in the area of open educational resources (OER). The aim of the report is to elaborate the concept of open educational resources, and provide a practically useful and theoretically solid definition of open educational resources.

In the summer of 2002, UNESCO organized the Forum on the Impact of Open Courseware for Higher Education in Developing Countries. One of the outcomes of the Forum was the concept of Open Educational Resources (OER). The concept spread rapidly. According to Johnstone (2005), its different interpretations by 2004 included:

- "Learning resources - courseware, content modules, learning objects, learner-support and assessment tools, online learning communities
- Resources to support teachers - tools for teachers and support materials to enable them to create, adapt, and use OER, as well as training materials for teachers and other teaching tools
- Resources to assure the quality of education and educational practices."[2]

In open educational resource initiatives, resources like the ones listed above are made widely accessible across the globe with low and no cost. The impact of open educational resource initiatives is potentially huge for learners, educators and educational institutions in the next years. This report will focus on this ongoing transformation, and contribute to it by developing the conceptual basis that can be used to study and discuss open educational resources. Specifically, we

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[1] Vest. C.M. (2006) Open content and the emerging global meta-university. Educause Review, May/June 2006, pp. 18-30, p.30.

[2] Johnstone, S.M. (2005) Open Educational Resources serve the world. Educause Quarterly, Number 3 2005, pp.15-8.

develop a theoretically justified and practically useful definition and characterization of open educational resources. Open educational resources include open-access digital journals and course material. In future educational models, educational resources, however, consist of more than "learning content." It is therefore important to understand how open educational resources can be characterized from technical, economic, pedagogical, and social points of view.

Many OER initiatives have been motivated by the ideals of open science. It has sometimes been argued that all knowledge should be openly accessible and reusable, so that it can lead to societal benefits. The creation of knowledge occurs incrementally, by reinterpreting and adding to the existing "body of knowledge." Proprietary and secret knowledge, therefore, can be viewed as unfair appropriation of the work of others. Particularly in the Western enlightenment movement, free knowledge has historically been perceived also as a key to individual freedom and social progress. As a result, the idea of free access to knowledge is deeply rooted in the norms of science.

From an economic point of view, free access to knowledge also creates problems, however. If knowledge is freely available, it is difficult for its creators to appropriate benefits of their work. During the last five hundred years, this has led to heated debates on the need and limits of intellectual property rights. This paper suggests that, from a policy point of view, it is important distinguish several different types of resources, some of which generate most social benefits when they are kept open. Specifically, we use open source software projects to highlight the possibility that some open resources increase in value when they are used. This puts open educational resources in a new economic context where resource scarcity is not the limiting factor, and where artificial scarcities may carry social costs.

An underlying claim in this paper is that open educational resources potentially transform the institutions of learning, the practices of teaching, and the processes of learning and knowledge creation. Open educational resources, therefore, cannot be studied only in the context of current educational systems.

OER will facilitate educational transformation in essentially two different ways.

It will be integrated in the existing educational practises, where the adoption of new technologies will gradually lead to new forms of practice. The impact and benefits of OER on existing practices can, in principle, be studied by analyzing how OER increases their efficiency.

OER will, however, also enable qualitatively new practices and new approaches in organizing education and learning. In this case, the potential benefits need to be described qualitatively. Efficiency, by construction, can only measure improvement in a given process and it cannot, by definition, compare the benefits of incomparable things. When educational processes and objectives qualitatively change, new systems are needed for measuring their performance and benefits.

The next Section 2 therefore briefly describes future learning environments and needs. Open educational resources will not only be used in traditional educational settings; instead, they will also enable new forms of learning. The benefits can be expected to be particularly visible in areas where they address present challenges and future needs.

Section 3 describes the sources and origins of the Open Educational Resources (OER) movement. Specifically, it discusses the open source development model, and the nature of "openness" in open source software and computer-based learning architectures. The section highlights two different types of openness: one that exists in the social domain, and which provides freedoms to use, collaborate, and distribute created systems; and another that can be found in the technical domain. Open source software systems have both technical and social openness; learning management system architectures, in general, are developed to support openness in the technical domain.

Section 4 will then discuss the nature of resources. A proper understanding of the concept is important for a useful definition of open educational resources. The concept of resource is a key concept in many disciplines. Sometimes it is understood as a static object stored in a repository, sometimes as a stock that generates a flow of services. Section 4 presents alternative views on the nature of resources, from economic to pedagogical and purely technical. What a resource is, in general, depends on the actor we are talking about. We, therefore, describe resources from a number of different perspectives.

Section 5 will then propose some characteristics of resources that are "open." The section distinguishes technically and socially open resources, and develops a three-level hierarchy of openness in the social domain. The section also argues that, for policy purposes, we need to study the nature of resources themselves. Some resources are essentially common pool resources that are rival, whereas others can better be characterized as public goods. The open source model, however, moves beyond these traditional categorizations, and can be characterized as an open fountain of goods. The historical development of intellectual property rights is tightly connected with the interpretation that science and knowledge are public goods. Section 5 therefore also briefly discusses the original goals of intellectual property rights.

Section 6 then develops then a definition of OER. It starts by briefly reviewing the definition proposed by UNESCO and elaborates five different views on the essence of OER: economic, social, learner-centric, and technical.

The Appendix describes examples of different types of OER initiatives. At present, there is a vast number of initiatives around the globe. We present some prototypical examples that help us categorize and characterize different types of OER. The examples in the Appendix also act as the empirical basis for validating the definition of OER presented in this paper.

Future learning environments

In the next years, social, political, and economic institutions and processes will see important changes around the world. The ongoing transformation towards the knowledge society will accelerate in high-income countries and gain momentum in developing countries. Knowledge and innovation are emerging as the main sources of economic growth and employment. Innovation, in turn, is becoming increasingly networked, multidisciplinary, and problem-oriented. Innovators will increasingly need good social, cultural, and communication skills, as well as capabilities to move between conceptual systems and interpretative horizons.

National systems of education and knowledge creation are now becoming linked to global knowledge networks in real time. New technologies, such as computer-based simulations and games, networked collaboration platforms, portable audio and video devices, and massively distributed content creation and learning management systems will enable new learning practices. Cognitive technologies will be used to repair defects in learning styles and to compensate the effects of aging. The costs of distributing high-quality learning materials will decline radically, as the materials are digitized and created in a digital form. Access to knowledge will increase in both developed and developing countries faster than anyone could have imagined just a few years ago.

As a consequence, educational systems will be redesigned for the production of new skills, utilization of new knowledge technologies, and for cost-efficient delivery of services in the global market of education. Education and learning will be integrated across the full lifetime of individual learners. The need to continuously update skills and knowledge will shift the focus towards adult education, particularly in those developed countries where demographic change increases the relative importance of elderly demographic groups.

Information and communication technologies are an important driving force in this change. The speed of change is also dramatic. New successful applications spread on the internet at astonishing pace, gaining tens and perhaps hundreds of millions of users in months or years. Skype, the free internet voice telephony service has now over 100 million users. The peer-produced encyclopedia Wikipedia has now over 5 million articles in over 100 languages. The free YouTube video sharing system has in one year grown its user base to about 60 million daily users, and it serves now over 100 million videoclips every day.[3]

It is clear that the new technical possibilities will have an impact on education and learning. We can already store thousands of books and hours of videos in our pocket. Digital storage is already two or three orders of magnitude cheaper than paper.[4] As broadband connections spread over the globe, the new possibilities will become a major driver for educational change and innovation.

Learning, itself, will become increasingly networked. The traditional educational models where learning was seen as "knowledge transfer" and "internalization" of pre-existing knowledge are now increasingly being replaced by active, social, and problem-oriented models. Learners are now asked to become creative and innovative. Classrooms become sites where knowledge is constructed by the students, and where teachers will organize and facilitate learning. The "sites" of learning, themselves, will become distributed, linking homes, workplaces, and educational institutions in novel ways across space and time. Information and communication technologies both drive this change and are being adapted for the new learning models and needs.

The origins of the OER movement

Open source

Thousands of open educational resources and courses are now available using the net, and the number is growing rapidly.[5] Since its start, the OER movement has been greatly influenced and inspired by the success of open source software projects. Open source software is computer software whose human-readable "source code" is published with a copyright that explicitly allows anyone to copy, modify and redistribute the code and its modifications without paying royalties or fees. SourceForge.net, the largest open source software development web site, now hosts over 130,000 open source projects.

The open source development model has led to impressive results. In September 2006, almost 60 million web hosts were using the Apache open source web server.[6] Almost all of these, in turn, were running on Linux or FreeBSD open source operating systems, and used other key open source applications, such as Perl, Python and PHP programming languages, and MySQL and PostgreSQL

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[3] Data on Wikipedia comes from http://meta.wikimedia.org/wiki/List_of_Wikipedias#Grand_Total, YouTube daily usage is calculated from Alexa traffic data: http://alexa.com/, assuming about 1 billion internet users in total. Skype subscriber data comes from Skype: http://about.skype.com/news.html.

[4] The estimate is based on data from Grochowski & Halem (2003) "Technological impact of magnetic hard disk drives on storage systems." IBM Systems Journal 42(2). The break-even for X-ray film and paper and flash memories occurred at about year 2000. Since then memory costs have dropped about two or three orders of magnitude. At a cost of one sheet of paper, you can now store in magnetic or semiconductor memories images of about thousand pages, without losing information.

[5] For example, the Open Educational Resource Archive at the Internet Archive stores now 1,627 items, at http://www.archive.org/details/education. The MIT OpenCourseWare has over 1,400 courses.

[6] http://news.netcraft.com/archives/web_server_survey.html

databases. Visible examples of successful open source projects include the Mozilla Firefox browser, the OpenOffice.org office application suite, the Azureus BitTorrent Peer-to-Peer file-sharing client, and many software tools used in educational settings.

The interest in the open source software development model has exploded during the last decade.[7] For educators, the open source model is interesting for four major reasons. These characteristics of open source have also motivated the OER movement.

First, the open source model requires that open source systems are freely available, without separate license contracts or fees. Although there may be some associated costs, such as basic computer and network connection costs, the users can download open source systems from the net without paying for the software.

Open source, therefore, has become particularly interesting in settings where money is a scarce resource. Many open source policy initiatives have focused on cost savings. A recent study by the British Educational Communications and Technology Agency (Becta), for example, found that the total cost per PC in primary schools was half the costs in non open-source schools, including costs for hardware, software, network, training, consumables, and formal and informal support.[8]

Second, open source development can produce high-quality systems that rapidly incorporate innovative ideas and useful functionality. Open source systems are typically developed in a distributed and modularized process that is fully transparent over the internet. Multiple participants, therefore, can effectively peer-review and improve the contributions of other developers. As many developers can simultaneously work on the system, focusing on their specific areas of expertise, this model potentially leads to very rapid development of high-quality outputs.

Third, open source licenses and the availability of source code make it possible for users to modify the system to the specific needs of the user. Thus, if the user has requirements that are not addressed by commercial software producers, the open source model allows the users to extend the system so that it addresses the important needs of the users. For example, the Ubuntu open source operating system distribution, which is based on Linux and the roughly 17,000 software packages in the Debian GNU/Linux distribution, specifically focuses on software that can be used across ages, languages and physical abilities.[9]

Fourth, the open source development model seems to be a very effective learning model. The history of Linux operating system, for example, shows that novice software developers have been able to rapidly become highly-skilled programmers and computer system architects. The informal communities of practice that develop open source systems have produced some of the leading software engineers of today. In some cases, open source projects seem to clearly outperform traditional formal educational models in their capability to create expertise and skills.[10]

Openness in open source

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[7] Raymond, E.R. (1998). The cathedral and the bazaar. *First Monday,* **3** *(3)* http://firstmonday.org/issues/issue3_3/raymond/; Tuomi, I. (2002). *Networks of Innovation: Change and Meaning in the Age of the Internet.* Oxford: Oxford University Press; Weber, S. (2004) *The Success of Open Source*. Cambridge, MA : Harvard University Press.

[8] Becta (2005): Open Source Software in Schools: A Study of the Spectrum of Use and Related ICT Infrastucture Costs. http://www.becta.org.uk/corporate/publications/documents/BEC5606_Full_report18.pdf

[9] http://www.ubuntu.com/ubuntu

[10] Tuomi, I. (2005) The future of open source. in Wynants, M. & J. Cornelis (eds.) *How Open is the Future? Economic, Social and Cultural Scenarios Inspired by Free and Open-Source Software*, VUB Brussels University Press, Brussels, 2005, pp. 429-59.

When successful, the open source software development model can lead to fast development, low costs, and high-quality outputs that closely match user needs. What, then, do we mean by "openness" in open source, and why does it matter? To what extent the concepts of "openness" that underlie open source software can be applied in other domains, for example in educational settings?

It is important to distinguish two domains where openness has fundamental consequences. The first is social, the second technical.

Openness in the social domain

Openness in the social domain can be summarized using the "four freedoms" of the free software movement. According to Richard Stallman, the founder of the Free Software Foundation:

> "Free software is a matter of the users' freedom to run, copy, distribute, study, change and improve the software. More precisely, it refers to four kinds of freedom, for the users of the software:
>
> - The freedom to run the program, for any purpose (freedom 0).
> - The freedom to study how the program works, and adapt it to your needs (freedom 1). Access to the source code is a precondition for this.
> - The freedom to redistribute copies so you can help your neighbor (freedom 2).
> - The freedom to improve the program, and release your improvements to the public, so that the whole community benefits (freedom 3). Access to the source code is a precondition for this.
>
> A program is free software if users have all of these freedoms. Thus, you should be free to redistribute copies, either with or without modifications, either gratis or charging a fee for distribution, to anyone anywhere. Being free to do these things means (among other things) that you do not have to ask or pay for permission."[11]

Generalizing the terminology slightly, one could consolidate the four freedoms to three: the freedom to use, the freedom to contribute, and the freedom to share.

According to Stallman, access to human-readable source code is not a purely technical issue; instead, it is a means for social ends. Software is used to implement ideas that can have important social benefits, and these ideas are often improvements over earlier ideas. Software development, therefore, is an accumulative process. Access to the earlier results of this process is necessary for progress in a similar way as access to scientific knowledge is a pre-condition for the advancement of science.

The Free Software Foundation, therefore, has defined the GNU General Public License, GPL, in a way that requires improvements built on earlier work to be submitted back to the "public domain." This approach is known as "copyleft." It uses copyright to guarantee the four freedoms of free software. In this case, "public domain," however, is protected by copyrights so that improvements on earlier work themselves enter this domain and accumulation of benefits is possible.[12]

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[11] http://www.gnu.org/philosophy/free-sw.html

[12] In copyright terms, "public domain" consists of works that do not have copyrights, usually because the copyright period has expired. The GNU GPL does not remove copyrights. Instead, it creates a "public domain" inside the copyright protected domain, adding moral "author rights" to those copyright legislations where author rights do not separately exist. A large number of free and open source licenses are now in use, some of which do not require that

Openness in the technical domain

Whereas openness in the social domain is fundamentally motivated by the expected social benefits and by ethical considerations related to human freedoms, openness in the technical domain, in contrast, is motivated by technical interoperability and functionality.

Technical systems are usually developed in the context of existing infrastructures. New systems can therefore often be viewed as components of larger existing systems. Improvements and additions to such systems can be made somewhat like scientific insights can be incorporated into the large existing body of scientific knowledge. In technical systems, however, the pieces in the existing system can well be proprietary and protected from unlicensed use. Novel and improved functionality can be integrated in technical systems only if system components are able to cooperate. This means that system designers have to define "interfaces" and "protocols" that describe how system components can be linked. Furthermore, these interfaces and protocols need to be standardized so that developers have a stable basis for the designs of new system elements.

In principle, technical interoperability standards can be either proprietary or open. Standards are, strictly speaking, defined by institutionalized standards organizations, such as the International Organization for Standardization (ISO), and if the standardization process is successful, standards are open.[13] In practice, however, many important standards are public specifications or "industry standards," jointly defined by key actors in a specific industry domain. For example, the Internet engineering community uses a mechanism for "Request for Comments," which produces RFC specifications that provide the foundation for the development of Internet technologies. Often these specifications have subsequently become adopted as international standards, as well.

Technical interoperability standards make it possible for independently developed systems to interact and co-exist. At the same time, they only define interfaces between systems, leaving the specific implementations of system components in a "black-box." Interoperability standards, therefore, allow new system components to be developed in a way that guarantees that they function as elements in the larger system, at the same time making it possible to link proprietary system components together. Industrial actors, therefore, put a great deal of effort to standardization.

Open source systems, as technical systems, go beyond this "co-existence" mode of interoperable modules. Although open source systems often rely heavily on existing interoperability standards and well-defined system interfaces, they also enable "deep interoperability." This is because open source developers can "see through" and make modifications across system boundaries. In open source systems, system components are not "black-boxes," which hide their internal structure and implementation. Instead, developers can also study the implementation of those components with which they want to integrate new components. The system elements in open source systems can be characterized as "white," "transparent" and "open" boxes. If effective implementation of a specific system element requires modifications in other system elements, the open source approach allows these.

The open source model, therefore, leads to a developmental dynamic that is different from the traditional one. Openness in technical interfaces leads to additive growth, where new components can be added to a larger system without major effort. The open source approach, in contrast, can lead to accumulation that produces compound growth. In other words, open source software has a

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improvements are freely shared. Cf. http://www.fsf.org/licensing/licenses/index_html, or http://www.opensource.org/licenses/.

[13] Although standards are developed as open standards, it is also possible that existing intellectual property rights limit the use of a standard. This can happen, for example, because an intellectual property owner has kept his rights secret during the standardization process.

different underlying innovation model than proprietary software, even when the latter is based on open standards.[14]

It is important to distinguish this form of technical and developmental "openness" from the free software freedoms. The freedoms of free software emphasize the rights of users. The underlying assumption is that whatever benefits come out of the development of software, they can be enjoyed in the society. The technical "deep interoperability," in contrast, enables an innovation dynamic that potentially leads to effective production of benefits. The latter increases the size of the pie, the former lets everyone to have a fair slice of it.

In technical systems, an important distinction can therefore be made between developmental and functional openness. Developmental openness is useful when new applications are created and integrated with existing systems and platforms. Barriers to achieving developmental openness can exist in many forms. They include limited access to information and to software development tools; legal restrictions, such as lack of access to relevant intellectual property rights (IPRs), contractual restrictions, and limits on reverse engineering; financial and economic constraints on undertakings in the present economic environment; and *de facto* monopolies resulting from a combination of these factors.

It is also possible to distinguish several abstract layers in technical systems and describe openness in each of these. In general, platform openness means that the different levels, for example, the network, application, and delivery layers, are transparent and accessible. Developmental openness, in addition to transparency, means that service creators are able to develop and connect new applications to the existing platforms.

Openness in computer-based learning architectures

In general, openness in technical development can lead to fast accumulation of benefits, better functionality through improved integration, and wider and faster diffusion of benefits. The economic conditions under which these potential benefits can be realized will be discussed shortly. First, however, it is useful to outline the different areas where "openness" could have a role in educational information and communication technologies. We can approach this task using existing architectures that have been used to define computer-based virtual learning environments. Below, we focus on three well-known initiatives, the Open Knowledge Initiative, the Schools Interoperability Framework, and the ELF e-learning framework.

O.K.I

The Open Knowledge Initiative (O.K.I.)[15] is a M.I.T. –led community effort that has defined a service-oriented architecture to facilitate the construction and use of educational applications. O.K.I. promotes specifications that describe how the components of a software environment communicate with each other and with other enterprise information and communications systems. The project is based on a modular and layered approach, which separates different types of services needed to support learning activities.

In this architecture, computer applications access components of the system as services, through well-defined and standardized application programming interfaces (APIs). The O.K.I. project defines these APIs in a software implementation independent way, as standardized Open Service Interface Definitions (OSIDs).

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[14] Cf. Tuomi, I. (2002) *Networks of Innovation.* Oxford University Press.

[15] http://www.okiproject.org/

The O.K.I architecture has two basic goals. First, by defining standard interfaces between layers, it separates abstract functionality from the exact way that this functionality in implemented. This means that modules can be implemented in many different ways, and that the system can, for example, evolve when new technologies become available. Second, when the underlying information system environment adopts the O.K.I. interfaces, high-level application and tool developers can develop their systems without knowing the specifics of the local implementation context.

The O.K.I. architecture rests on a local institutional computer *infrastructure* that provides basic functionality such as security, user authentication, file storage, database management, logging, and communications. These infrastructures are implemented in different ways in different educational institutions. Higher-level *common services* therefore access these basic services through application programming interfaces. This architectural layering is shown in Figure 1.

For example, the O.K.I. conformant file API can be used to access the underlying computing infrastructure to store various types of files and directories, with metadata such as owner, quota, versioning, and file type. Common services are therefore defined in a way that is independent of the specifics of the underlying infrastructure, and they may also extend the basic functionality provided by the infrastructure. Typically, for example, basic file storage infrastructure does not store information about file versions.

The O.K.I. architecture defines a level of *educational services* on top of the common services. Educational services are services such as content and course management, assessment, and digital repositories that are available to the institution's applications in the provision of e-learning.

Finally, educational applications can use the provided educational services through a second set of standardized APIs. The full layered model is shown in Figure 1.

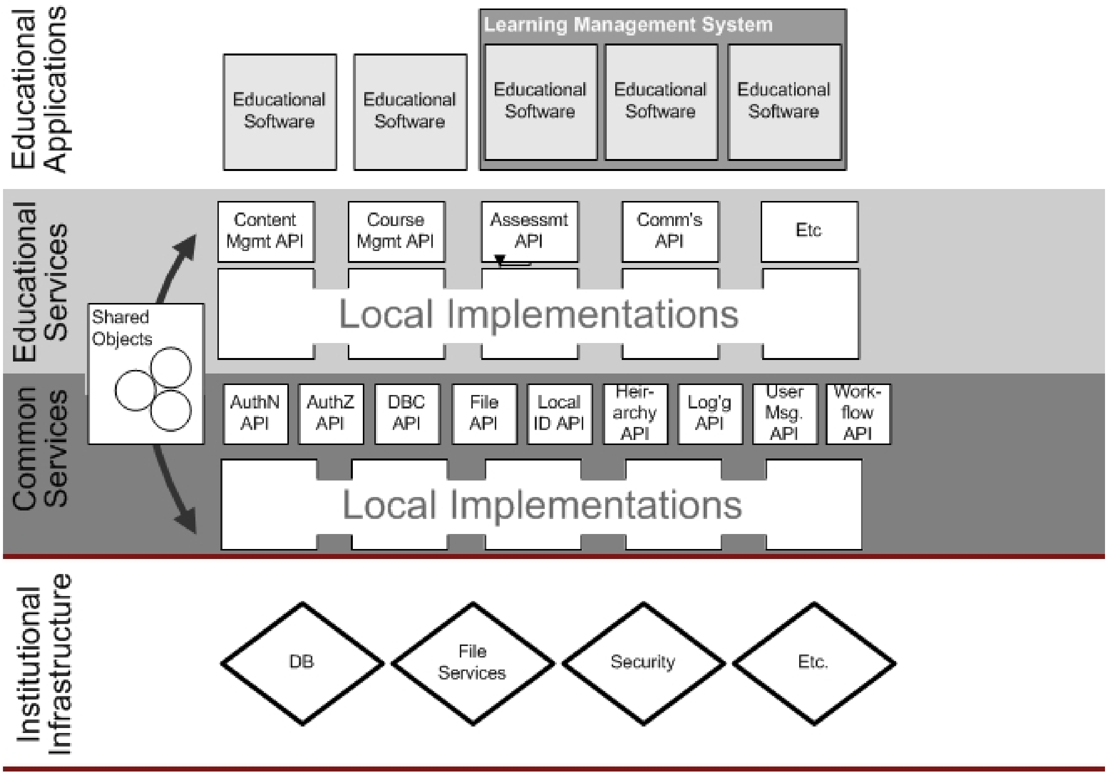

Figure 1. The O.K.I. architecture.[16]

SIF

The O.K.I. architecture follows a very common layered programming model, where abstract system layers are connected via standardized protocols and interfaces.[17] Another approach is based on creating a separate "middle-ware" system that links a set of independent systems together. This approach is often used to connect existing systems that have been developed without standard interfaces and which need to communicate. In effect, a middle-ware component builds a "bridge" or "gateway" between different systems.

An example of this approach is the Schools Interoperability Framework (SIF). SIF is an industry initiative to develop a set of technical specifications for ensuring that K-12 instructional and administrative software applications work seamlessly together. It defines software implementation guidelines for SIF compatible systems, with the goal of ensuring that all compliant applications can achieve interoperability, regardless of how they are implemented. SIF uses a SIF Zone Integration Server to connect the various software systems in the school together. As many schools use legacy systems and applications that do not know about SIF standards, the architecture relies on software agents that mediate communications between the independent systems and the SIF middleware Zone Integration Server.

The SIF architecture is shown in Figure 2.

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[16] http://web.mit.edu/oki/learn/whtpapers/arch_overview.html

[17] Many communication and computing systems, including the Internet itself, rely on the layered OSI model, standardized by ISO. The ISO/OSI model has seven layers, starting from the specifications of the physical level and extending to the application layer.

Figure 2. Schools Interoperability Framework.[18]

SIF provides an architectural view on school information and communication systems as they are seen by information systems specialists and administrators. In this view, food services and library automation, for example, are important services that enable effective learning to happen. "Instructional services" are, in this framework, only one element, among many, in a bigger educational service system.

ELF

Whereas SIF reflects an information system administrator perspective, the e-Learning Framework (ELF), in contrast, focuses on "instructional" services, and describes in more detail these. ELF is an international effort to develop a service-oriented approach to the development and integration of computer systems in the sphere of learning, research and education administration.[19] One could also view it as an extension of the O.K.I. architecture. ELF, however, is explicitly defined as a framework and not as a technical architecture. It tries to provide a technical framework where different elements of a learning system can be described and developed.

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[18] http://www.sifinfo.org/

[19] http://www.elframework.org/

ELF uses a service-oriented approach in describing system elements and their interactions. In a service-oriented approach, granular functional components expose service behaviours that are accessible to other applications via loosely coupled standards-based interfaces.

In a sense, the ELF framework provides a vocabulary and grammar that can be used by individual organizations to describe how their systems work together. The service-oriented approach is now widely used to create web-based applications and Service Oriented Architectures (SOA's), and it underlies also the O.K.I. architecture. From software developer's point of view, the basic vocabulary and grammar needed for ELF, therefore, are parts of the dominant language, and the basic concepts are rather obvious to technical people.

The ELF framework is shown in Figure 3.

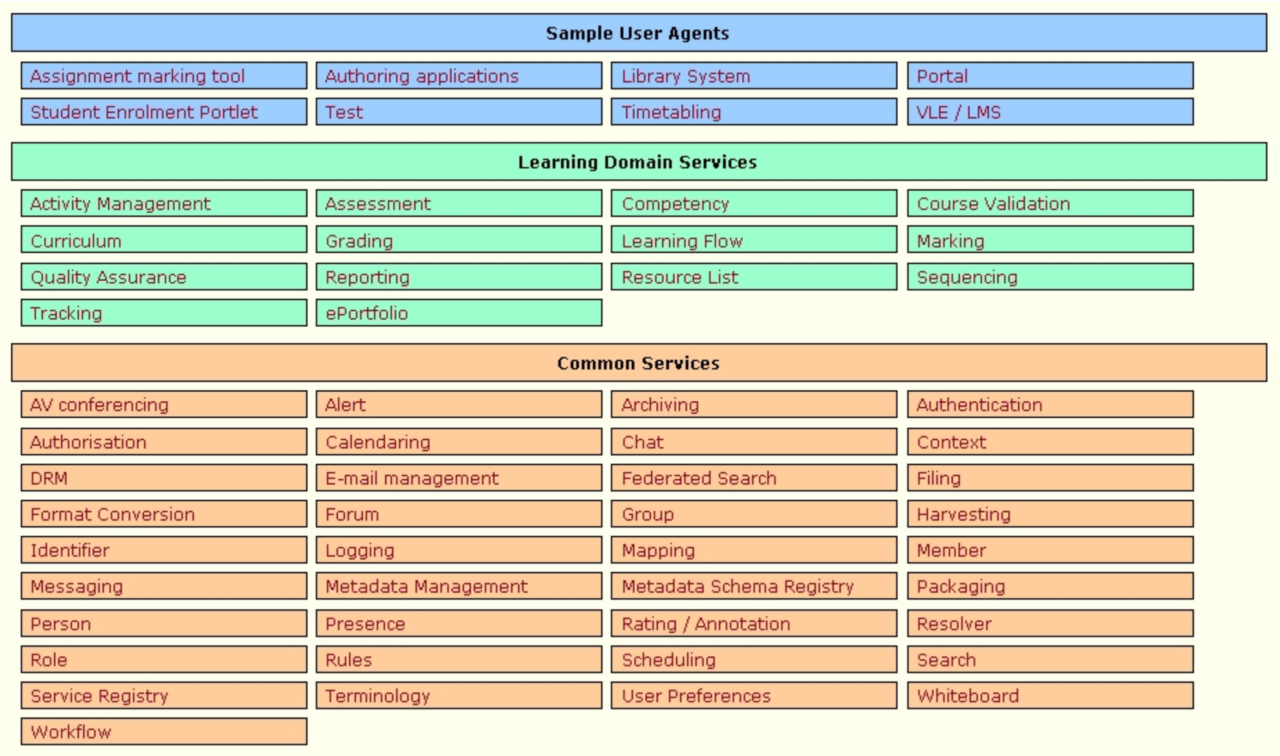

Figure 3. The layers and services in the E-Learning Framework (ELF).[20]

A graphical representation of ELF reveals the complexity of information and communication systems that form computer-based educational infrastructures. In principle, one could focus on any of the blocks in Figure 3 and ask whether it should be "open." In ELF, they would be open in the sense that their interfaces would be well specified and the definitions would be publicly available.

In the above described architectures and frameworks, openness is, in the first place, about technical interoperability. Open standards and interfaces guarantee that systems can operate as elements in a larger system. The elements, themselves, can be either open or closed. An important motivation to create such architectures, indeed, is to guarantee that the various commercial and proprietary systems needed in educational settings can work together, and that requirements for such systems can be described in vendor-independent ways.[21]

[20] http://www.elframework.org/

[21] This the main motivation for the Sharable Content Object Reference Model (SCORM), developed by the Advanced Distributed Learning initiative funded by the U.S. Department of Defense. Cf. http://www.adlnet.gov/scorm/index.cfm.

From a technical point of view, one could therefore describe openness in educational computer-based environments as open interoperability standards. The existence of open standards, however, does not say very much about the terms and conditions under which these standards can be used. An open specification of application programming interfaces may be necessary for effective access to document repositories, for example. Such open standards, of course, do not necessarily imply that the repository consists of documents that can be openly and freely accessed and used.

The openness of the interfaces and the openness of the systems that implement the underlying services are important components of open systems, however. In fact, many components of O.K.I. and ELF are also being implemented as open source.[22] Openness, therefore, can in these cases also be characterized as "deep interoperability" and developmental openness.

One needs, however, to ask whether the different elements in frameworks such as ELF properly should be called "resources." It may be natural to think that educational resources comprise of digitized texts and learning materials. A "future-proof" definition of open educational resources can not only be limited to documents and files in a repository, however; it has to encompass key services beyond file storage. The elements in ELF are educational tools and services provided by computer systems. But which of these should be included in a definition of educational resources?

To address this question, we have to elaborate the concept of "resource."

Resources in learning environments

According to the Oxford English Dictionary definition, "resource" is a stock or supply of materials or assets that can be drawn on in order to function effectively. The term is now used in widely varying contexts. Its origin is the Latin word resurgere, re- + surgere, a combination of the verb "to rise" and a prefix that indicates recurrence and repetition. Etymologically speaking, resource, therefore, is a source that keeps acting as source, at least as long as it does not run out.

One could define renewable resources as something that can be drawn upon without diminishing the stock, and non-renewable resources as stocks that decrease when used. Knowledge is often described as a renewable resource. Digital resources can be copied without destroying the original stock, and therefore they also could be characterized as renewable resources.

In an economic sense, resource is something that requires effort to create or recreate, and which produces a flow of services. In this view, all investments in educational systems create resources. For example, investments in school buildings, libraries, teacher training and administrative processes create educational resources. From a policymaker's and administrator's point of view, open educational resources could, therefore, include school facilities and public libraries that can be freely accessed for educational purposes.

In this economic sense, service-based computer architectures, by definition, consist of resources. The creation of common services and learning services in the ELF framework, for example, requires effort. When the components are implemented, they provide services that are consumed by the educational applications and tools, and eventually by the users of the system.

The term resource is, however, often used more narrowly. In many computer-based learning systems, resource is understood as learning content that can be stored in a digital repository as a

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[22] The O.K.I. open source documentation and implementations are available at http://sourceforge.net/projects/okiproject.

text, audio, or video file. According to IMS Global Learning Consortium, resources are "assets" or as collections of "assets":

> "A resource element is a container for a particular asset or collection of assets. A resource may contain references to assets that are all of the same type or different types (i.e., file formats)." [23]

In the IMS Global Learning Consortium Content Package specification, resources can be more than learning content, however. The resources in IMS Content Packages can refer, for example, to:

- reusable competency and educational objective definitions
- other IMS content packages
- learning designs that define specific pedagogical models and the ways in which resources are used in them
- information packages about specific learners
- meta-data
- interoperable question and test packages
- vocabulary definitions
- resource lists

All the above are digital resources in IMS Content Packages. The IMS information model defines resource as "any *digital* entity (e.g., *file, Web service*) that is accessible by means of resolving its Uniform Resource Identifier ..."[24]

IMS, therefore, intentionally narrows the scope of the term from its standardized use in the Internet development community. This standardized usage can be found from the Internet Task Force Request for Comments specification[25] that defines Universal Resource Identifiers. According to Berners-Lee et al., Uniform Resource Identifier (URI) provides a simple and extensible means for identifying a resource. The specification of URI syntax and semantics is derived from the concept of Universal Resource Locator (URL), introduced in the World Wide Web initiative in 1990.

The specification of "Uniform Resource Identifier (URI): Generic Syntax" explains:

> "This specification does not limit the scope of what might be a resource; rather, the term 'resource' is used in a general sense for whatever might be identified by a URI. Familiar examples include an electronic document, an image, a source of information with a consistent purpose (e.g., 'today's weather report for Los Angeles'), a service (e.g., an HTTP-to-SMS gateway), and a collection of other resources. A resource is not necessarily accessible via the Internet; e.g., human beings, corporations, and bound books in a library can also be resources. Likewise, abstract concepts can be resources, such as the operators and operands of a mathematical equation, the types of a relationship (e.g., 'parent' or 'employee'), or numeric values (e.g., zero, one, and infinity)."[26]

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[23] http://imsglobal.org/xsd/imscp_v1p2.xsd

[24] http://imsglobal.org/content/packaging/cpv1p2pd/imscp_infov1p2pd.html

[25] Berners-Lee, R. Fielding, and L. Masinter (2005) Uniform Resource Identifier (URI): Generic Syntax. http://www.ietf.org/rfc/rfc3986.txt

[26] http://www.apps.ietf.org/rfc/rfc3986.html

The Internet community therefore defines the concept of "resource" as anything –physical, digital or immaterial– that can be pointed to, using a well-formed "universal resource identifier."

This concept of "resource" is extremely broad. For example, it includes services and abstract resources. If fact, one may at first think that the problem with this conceptualization is that it is so broad that it encompasses everything that exists in any real of fictional universe. One could then try to limit the scope of this definition so that it "points" to resources that are relevant in discussing open educational resources.

This approach would miss an important point. First, we should as whether the world, in fact, consists of things that can be pointed to with a "universal resource indicator." In other words, we should ask how "universal" a URI actually is. What things a URI can not point to?

This not a trivial question, and it can only be answered by describing alternative epistemological and ontological views that have been developed in different philosophical traditions. The important point is that the concept of URI, indeed, emerges from within a specific philosophical view, and that it looks most natural in that specific philosophical context.

Objects or flows?

In fact, the concept of URI makes best sense if we adopt a Platonic view, where the world consists of "eternal objects." It still makes practical sense if the "objects" of the world are not exactly "eternal" but, for example, something stable enough that their "objectness" is important for practical purposes.

The Platonic view of the world can usefully be contrasted with the one described by Heraclitus. Heraclitus, in the 6th century BCE, argued that "everything flows and nothing stays still." This is known as the principle of "panta rhei." According to Heraclitus, "you cannot step twice into the same river, for other waters and yet others go ever flowing on."[27] In this view, stability is an illusion and only change is real.

The Platonic view has been a very important element in many Western philosophical traditions. It is deeply embedded in many empirical sciences and common-sense concepts. Several philosophers, however, have also pointed out the limitations of this view. For example, according to the philosopher Henri Bergson, change itself is something that can not be described from this point of view. Most importantly, Bergson argued, the natural human tendency to conceptualize the world as objects necessarily makes evolutionary processes and living systems unexplainable. The object-based view of the world, therefore, is a wrong starting point if we want to understand human thinking and cognition, for example.[28]

One could therefore claim—summarizing Bergson's more extensive analysis—that URIs exist in a philosophical world where, for example, change itself and the essential characteristics of the human mind remain invisible. You can point to an abstract river, but you cannot point to the fact that the river is not the same anymore. In other words, if the essence of the river is its flow, you miss the point.

Another challenge for Platonic pointers is crystallized in the concept of "tacit knowing." In Michael Polanyi's terms, knowing always requires a context of unarticulated meaning that provides the background against which focal knowledge can become explicit.[29] Explicitly stated knowledge can

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[27] Heraclitus fragments are available with English translation and comments by William Harris at http://community.middlebury.edu/~harris/Philosophy/heraclitus.pdf.

[28] Cf. Bergson, H. (1983). *Creative Evolution (first edition 1907).* Lanham, MD: University Press of America.

[29] See, for example, Polanyi, M. (1967). *The Tacit Dimension.* New York: Anchor.

only exist in a "field" where much of the knowledge remains unarticulated background. Objects, similarly, exist only because their perceiver makes them stand up from a background context that is not perceived as objects. The meaning of an object, therefore, emerges from a complex field of meanings, most of which remain unarticulated and tacit. You cannot point to such a dynamic sets of relations that underlie all possible ways to "objectify" the world. As a consequence, you cannot point to the meaning of things using an URI.

The third challenge to the object-centric interpretation of resources has been posed by James J. Gibson, the founder of ecological psychology. According to Gibson, when we see a chair, we do not see four legs of a chair, seat, and a back of the chair, from which our brain infers that we, indeed, perceive an object that can be called a chair. Instead, we live in a relationship with the world in which we live, and observe it as potentially useful and meaningful things. Things that "afford" sitting are perceived as chairs. The "objects" of the world, therefore, emerge as relations between active actors who go on in a world and their lived environment. "Objectness," therefore, should be understood as a relation between subjects and objects that are dynamically constructed by these subjects as they move in their world.[30] The "universality" of an URI, therefore is specific for each subject. Even if you can point to a resource, one still has to ask who it is, who is pointing.

The object-centric view of the world is a very characteristic feature of Western history of ideas. Asian philosophical traditions, in contrast, often emphasize the primacy of flows. In Tao Te Ching, Tao, itself sometimes translated as "flow," is described as a resource. It is "like an empty vessel / that may still be drawn from / without ever needing to be filled." According to Tao Te Ching, Tao itself is something that a URI can never point to:

> "A way that could be named or expressed,
>   has not the true Essence of the Way.
> A name that could be called or sounded,
>   has not the true Essence of the Name."

A philosophical analysis of technical concepts like a URI may perhaps feel unnecessary for computer scientists who have learned to live with Platonic concepts. It is, of course, not possible to discuss the practical relevance of such philosophical analysis in any great detail here. It is, however, important to realize that such "innocent" looking technical concepts as the URI make sense only if we also adopt a specific view of the world with them. Computer science is to a great extent built on Platonic models of reality, and many computer and software architectures start from this model as a natural starting point.

In general, the different philosophical traditions, however, lead to different views on the nature of knowledge and learning.[31] They also lead to different "ontologies" and "resources." In the present context it is sufficient to note that different ontologies exist, and that the Platonic model of object-

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[30] Gibson, J.J. (1950). *The Perception of the Visual World.* Cambridge, MA: The Riverside Press.

[31] According to Nishida Kitaro, the founder of the Kyoto School of philosophy, the Western approach of starting from the separation of subjects and objects has been the main source of confusion in the history of Western philosophy. Cf. Nishida, K. (1987). *Last Writings.* Honolulu: University of Hawaii Press. In Asian thinking, the distinction between "objects out there" and the "subject in here" is often considered to be an illusion, for example, because we, as perceiving subjects are also processes of the world. The world produces simultaneously both its subjects and objects, and they exist as subjects and objects only in a relationship, where, strictly speaking, the separation hides their essence. This point is developed in great detail by Nishida, for example. As noted, computer scientists usually follow Platon and rarely question the primacy of objects. Educational theorists, in contrast, have developed quite sophisticated views on the nature and dynamics of objects. In the context of cultural-historical activity theory, for example, the concept of object has a central theoretical position. Cf. Stetsenko, A.P. (1995). "The role of the principle of object-relatedness in the theory of activity," *Journal of Russian and East European Psychology*, **33** (6), pp.54-69.

centric world does not necessarily lead to universality. Instead, it may make invisible processes that are dynamic and relational and where, for example, meaning is relevant.

The economic concept of resources integrates in an interesting way the flow and object views. The economic concept is based on viewing resources as sources of flows. In economic sense, the river, as a producer of flow, is the resource, and the flow is the service that the river produces. Economists, therefore, could say that you perhaps cannot step into a river twice but you can drink twice from it. The fact that you can drink from it twice makes the river a resource.

An important practical difference between the Internet community definition of resources and the economic definition is that the former remains agnostic about the benefits of resources. Universal Resource Identifiers simply point to “resources.” Anything that is stable enough to be pointed to, is a resource. The economic concept, in contrast, requires that resources generate services. The economic approach, therefore, allows us to ask what kinds of services are being created, at what costs, and who can enjoy the benefits.

Resources as learning objects

It is possible to imagine resources that one can not “point to.” For example, the network view on social capital sometimes interprets social capital as a pool of accumulated weak and strong social ties that can be mobilized to achieve specific objectives.[32] In learning theory, such social capital can be an important descriptive and explanatory factor. It may be difficult or impossible to point to resources that, for example, exist in a form of structural networks and dynamic interactions. As a result, there can be educational resources that we cannot point with a URI.

The URI may, however, also have a scope that is too general. A URI can point to anything that can be pointed to. This includes services, abstract conceptual objects, and fictional and counterfactual things.

In computer-based learning system architectures, the concept of resource is often used in a more narrow sense. Often it refers to digital versions of traditional course materials. An important extension of this approach has been the idea that learning content can be modularized and packaged as “learning objects.”

Learning objects became very popular among educational technologists in the late 1990’s. The idea was an extension of the object-oriented computer programming model. In contrast to traditional procedural programming, where the program basically consists of a list of instructions, object-oriented systems are designed as modularized and relatively independent “objects” that interact using messages or well-specified interfaces. Objects are derived from generic “object classes” by specifying their distinctive behaviours –known as methods– and by defining attributes that make the object unique.

Applying the basic principles of object-oriented design in educational contexts led to the idea that elements of educational content can be packaged in standardized and re-usable modules, which can then be combined to produce high-quality learning experiences. This idea has proven to be more difficult to implement than originally thought. It is now commonly observed that the early visions were not particularly well connected with sufficiently sophisticated pedagogical models.[33] The

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[32] Granovetter, M. (1973). The strength of weak ties. *American Journal of Sociology,* **78** *(May),* pp.1360-1380. Coleman, J. (1988). Social capital in the creation of human capital. *American Journal of Sociology,* **94** *(Supplement),* pp.95-120.

[33] Littlejohn, A. (2003) Issues in reusing online resources. Reusing Online Resources (Special Issue) Journal of Interactive Media in Education, 2003(1), pp. 1-7. Wiley, D (2000) Connecting learning objects to instructional design

concept is still, however, frequently used to refer to "packaged learning content." The IEEE Learning Technology Standards Committee (IEEE LTSC) defines Learning Objects as any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning.[34]

This definition is quite broad. Basically, it adopts the URI model or reference, adding the requirement that the resources can be used in technology supported learning. Several "content models" have tried to provide more precise definitions and identify the types of content that a learning object may consist of. These include the Sharable Content Object Reference Model (SCORM) Content Aggregation Model, the Learnativity content model, and the CISCO RLO/RIO model.

The SCORM content aggregation model consists of assets, Sharable Content Objects (SCOs), and content aggregations. Assets in the SCORM model are electronic representations of text, images, audio, web pages, and other content that can be presented in a web client. A Sharable Content Object is a collection of one or more assets. SCOs are intended to be small content packages that are independent of learning content, so that they can be easily re-used. In SCORM, a "learning resource" is a SCO or an asset. Content aggregation refers either to the process or the end result of building a specific learning experience from content objects and assets. Content aggregations can be, for example, courses, chapters, or study modules. [35] SCORM uses the IMS Content Packaging specifications, discussed above.[36]

The Learnativity content model, in turn, distinguishes five levels of content aggregation.[37] First, *raw media elements* exist at the data level. Examples include a text paragraph, an image, or an animation. The second level consists of *information objects* that are sets of raw media elements. For example, a number of paragraphs could form an information object that consists of a summary of a topic. The third level then organizes a set of information objects based on a single learning objective into an *application specific object*. For example, a number of information objects can be organized into a course module that has a well-specified learning objective. At the fourth level, the application specific objects are then aggregated into *aggregate assemblies* that support a more generic learning objective, for example, a full lesson. Finally, the fifth level *collections* aggregate these assemblies around a broader theme, for example into courses and whole curricula.

The Learnativity content model is a hierarchical model, where raw media elements are aggregated to content modules that fulfil a partial objective, and where such partial objectives are gradually organized into larger objectives. This approach follows a "top-down" design method, where a larger overall task is decomposed into smaller ones, and eventually the lowest-level activities are linked with raw media elements.

In principle, the Learnativity model provides a conceptual hierarchy, without much constraining the elements or the structures that form the different aggregations. In contrast, the CISCO Reusable

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theory: A definition, a metaphor, and a taxonomy. In D. A. Wiley, ed., *The Instructional Use of Learning Objects*: Online Version: http://reusability.org/read/chapters/wiley.doc

[34] http://ieeeltsc.org/wg12LOM/

[35] http://www.adlnet.gov/Scorm/index.cfm

[36] http://www.imsglobal.org/specifications.html

[37] Wagner, E.D. (2002) Steps to creating a content strategy for your organization. The eLearning Developer's Journal, October 2002.

Learning Object (RLO) model has a very specific structure.[38] Each RLO in the CISCO model contain 7 ± 2 Reusable Information Objects (RIOs). In addition, a RLO also has an overview section, a summary section, and assessment module. Each RIO, in turn, is composed of three components: content items, practice items, and assessment items. An assessment item is a question or a measurable activity that can be used to determine whether the learner has mastered the learning objective for the given RIO. Each RIO is one of a five different types: concept, fact, procedure, principle, or process. The CISCO RLO/RIO model is shown in Figure 4.

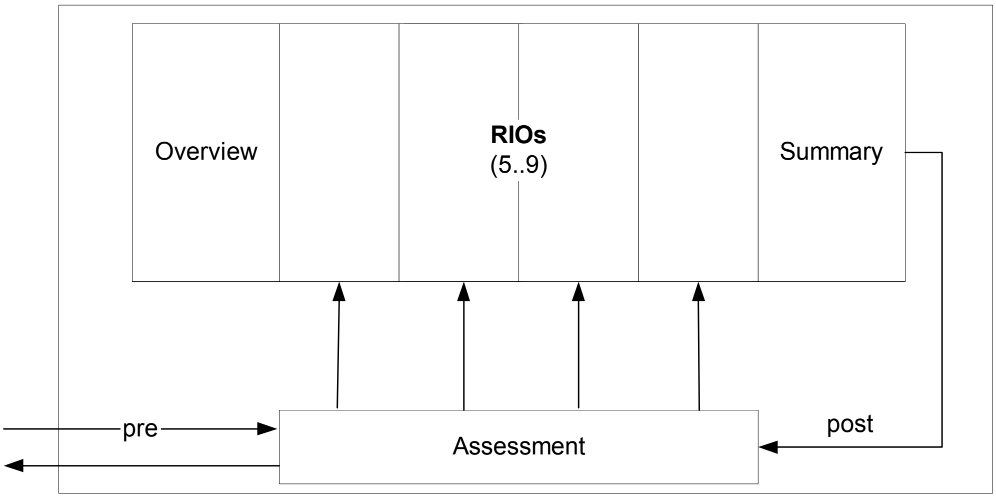

Figure 4. The Cisco RLO/RIO model.

The Cisco RLO/RIO model aims at building learning objects that are reusable and media independent. The idea is that a RIO can be developed once, using a structured development methodology, and delivered on multiple platforms. The RLO/RIO development strategy was specifically intended to deliver knowledge and skills on self-paced media-driven platforms such as the Web.

The pedagogical model in the RLO/RIO approach reflects a "lone learner" "knowledge transfer" model, where a single learner interacts with content and internalizes it in the learning process. This is the case also for most of the IMS specifications. In general, the concept of "learning content," emerges most naturally when learning is viewed as transfer of existing knowledge into the minds or brains of students.

In more constructivist models, learning is perceived as an active process, where the learner creates knowledge. In these models, "learning content" –for example knowledge documented in textbooks– is just one asset among many that can support the learner in the process of creating knowledge. The aim of learning in such models is not to convey knowledge or information into the learners head. Instead, the aim is to facilitate the building of cognitive capabilities that make intelligent action and thinking possible. Such pedagogical models are more difficult to automate than the traditional "knowledge transfer" model. They tend to emphasize innovative learning, where learners may create new knowledge, thus making it more difficult to assess whether learning has indeed occurred. The pedagogic objective in constructivist models may be a much more open-ended goal of cognitive development, and in some pedagogical approaches the aims may include the development

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[38] Barrit,C., D. Lewis, and W. Wieseler (1999) Cisco Systems Reusable Information Object Strategy: Definition, Creation Overview, and Guidelines. Cisco, 1999. Available at: http://www.cisco.com/warp/public/779/ibs/solutions/learning/whitepapers/el_cisco_rio.pdf.

of collaborative work practices, or social learning that changes, for example, everyday practices and social institutions.[39]

Although the early IMS Global Learning Consortium specifications were developed mainly in the context of the traditional "knowledge transfer" pedagogical model, more recently the IMS specifications have also enabled the description of alternative pedagogical models. The IMS Learning Design specification,[40] in particular, is intended to support the definition of different pedagogic models. It also allows "units of learning" that simultaneously include several roles, each of which can be played by several actors. It thus supports both group and collaborative learning of many different kinds. Rather than attempting to capture the specifics of each of many pedagogical models in equally many specific schemas, Learning Design provides a generic language that allows many different pedagogies to be expressed. Learning Design specifications are built on the EML Educational Modelling Language that was originally developed at the Open University of the Netherlands, after comparison of several pedagogical approaches and their associated learning activities. EML describes not just the content of a unit of study (texts, tasks, tests, assignments) but also the roles, relations, interactions and activities of students and teachers.[41] Learning Design similarly separates learning activities from activity structures, and these from roles and resources. These all can be reused as components. Learning Designs organize the components as "plays" that consist of one or more "acts" preformed by one or more "roles." [42]

Resources for whom?

The various learning object content models have tried to describe what, exactly, goes into a learning object. Implicitly, these models focus on resources that consist of content fragments, navigation through the learning experience, and specified learning objectives.[43] In these models, resources are viewed from the learner's point of view.

From the learner's point of view, the standard dictionary definition of resource works well. A resource can be "any stock or supply of materials or assets that can be drawn on in order to function effectively." From studies on social, constructivist, experiential, pragmatic, and activity-theoretic models of learning, as well as from ethnographic studies, we know that learners can mobilize many different types of "assets" for learning. For example, children can "borrow" cognitive capabilities of their peers and parents.[44] Adult learners often use their "social capital" to gain access to expert advice. Learning can also be situated in physical and social contexts that support learning and competence development, and people often use concrete material artefacts to facilitate learning

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[39] Alternatives to the "knowledge transfer" model have been discussed, for example, by Jarvis, P. (1992). *Paradoxes of Learning: On Becoming an Individual in Society.* San Francisco, CA: Jossey-Bass Publishers; and Engeström, Y. (1996). *Non scolae sed vitae discimus*: toward overcoming the encapsulation of school learning. In H. Daniels (Ed.), *An Introduction to Vygotsky.* (pp. 151-170). London: Routledge.

[40] http://www.imsglobal.org/learningdesign/.

[41] http://eml.ou.nl/introduction/explanation.htm

[42] http://www.imsglobal.org/learningdesign/ldv1p0/imsld_bestv1p0.html

[43] Verbert and Duval argue that most of the well-known content models can be decomposed into content fragments, navigation structures, and learning objectives. Cf. Verbert, K., and E. Duval (2004) Towards a global component architecture for learning objects: a comparative analysis of learning object content models. In Cantoni, L. and C. McLoughlin (eds.) Proceedings of the ED-MEDIA 2004 World Conference on Educational Multimedia, Hypermedia and Telecommunications, pp. 202-8.

[44] A classical statement of this view can be found in Vygotsky, L. (1986) *Thought and Language.* Cambridge, MA: The MIT Press.

processes.[45] Learners can also learn by creatively using resources that have not been intended for learning purposes.[46] The traditional "knowledge transfer" model of learning where educational content is "internalized," therefore conveys a rather limited view on the large variety of potential learning resources, when they are perceived from the learner's point of view.

However, also the idea that a resource is a "stock" can in some cases be problematic. For example, many open source software development projects are supported by instant messaging channels, where the developers can ask for help and advice when they encounter a problem. These channels can be very important support mechanisms. Yet, there is no traditional "stock" associated with such dynamically generated services. In computer-supported learning environments, similar real-time support can be produced by peers, mentors, experts, or teachers, for example.

From the teacher's point of view, learning resources are commonly perceived through their pedagogical intent and purpose. From this perspective, learning resources are assets that are provided to learners with the intent that they are of service in the learning process. In conventional instructional settings, resources are for teachers something that can be used to make teaching easier or more effective. In this view, a prototypical learning resource is a textbook or –on a more abstract level– a library. This view is easily extended to one which understands learning resources as digital multimedia content collected in a repository.

Teachers often also switch to a more administrative view on resources. Lack of educational resources can, then, mean, for example, unavailable class room space, printers without paper, too few pencils and chairs, or difficulty or finding qualified teaching assistants.

The provision of educational services, however, is also a social endeavour. Educational resources require investment, and education is in many countries one of the largest components of national budgets. Policymakers may be less interested in the specific educational experience generated by educational resources but they certainly are interested in their overall social impact. For example, if the wide availability of "open" educational resources leads to lower costs in the provision of educational services, improved educational outcomes, faster growth of human capital and human capabilities, and effective support for national innovation systems, this would be important for policymakers to know. A useful definition of educational resources will allow also such a macro-level social consequences to be described and discussed.

In social theory, the concepts of resource, agency, power, and rules are tightly integrated. According to Giddens, resources are structured properties of social systems, drawn upon and reproduced by knowledgeable social agents in the course of social interaction.[47] In this view, resources are the "media through which power is exercised."[48] Rules and resources jointly define the social structure, as transformations that produce and reproduce the structure. Giddens distinguishes three interdependent domains of structure: one that has to do with communication and signification of things; another that has to do with power and domination in social relations; and a third that has to do with norms and legitimation of social interaction. According to Giddens,

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[45] See, for example, Scribner, S. (1997). *Mind and Social Practice: Selected Writings of Sylvia Scribner.* Cambridge: Cambridge University Press; Rogoff, B. (1990). *Apprenticeship in thinking: cognitive development in social contexts.* New York: Oxford University Press; Lave, J., & E. Wenger. (1991). *Situated Learning: Legitimate Peripheral Participation.* Cambridge: Cambridge University Press; Suchman, L. (1987). *Plans and Situated Actions: The Problem of Human-Machine Communication.* New York: Cambridge University Press.

[46] For example, many computer programmers have learned advanced programming skills by "cracking" software copy protection systems and by participating in open source development projects.

[47] Giddens (1984), The Constitution of Society: Outline of the Theory of Structuration. , Cambridge: Polity Press, p.15.

[48] ibid., p.16.

domination depends upon the mobilization of two distinguishable types of resources. Allocative resources refer to capabilities for generating command over objects, goods, and material phenomena. Authoritative resources, in turn, refer to types of transformative capacity generating command over persons or actors.[49] Any coordination of social systems across time and space necessarily involves a definite combination of these two types or resources. According to Giddens, they can be classified as in Table 1.

Allocative Resources	*Authoritative Resources*
Material features of the environment (raw materials, material power sources)	Organization of social time-space (temporal-spatial constitution of paths and regions)
Means of material production / reproduction (instruments of production, technology)	Production / reproduction of the body (organization and relation of human beings in mutual association)
Produced goods (artefacts created by the interaction of material features and the means of production).	Organization of life chances (constitution of chances of self-development and self-expression)

Table 1. Allocative and authoritative resources in structuration theory.[50]

The sociological analysis of resources highlights the point that allocative resources really become resources only if they are accompanied by the authority to use them. Societies are structured by norms, rules, and structures of communicated meanings that regulate its activities and social interactions. One can improvise around existing structures, turn constraints and rules into resources, and creatively apply resources for unintended purposes. Resources, therefore, are also dynamic. They become defined as resources only at the point where someone starts to make use of them as transformative powers in the ongoing social practice. The openness or resources, therefore, also has to do with the question who is allowed to allocate and mobilize resources, and in what points in the social time-space this is allowed in the society.

In defined resources, it is important to note that different actors have different points of view, and they often speak different languages. Sometimes they use concepts that look the same but which have different meanings. In practice, successful implementation of new technical systems requires that different points of view and different practical interpretations are taken into account. Educational resources are not something that can be fully defined using the language of a teacher, learner, policymaker, or school administrator. Economists, sociologists and technologists approach resources from different perspectives, and highlight different aspects of them. Although it may be justified to give emphasis to the specific perspective of learner, as the central actor in the learning process, if the other perspectives and stakeholders are not taken into account, many practical initiatives will fail.

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[49] ibid, p. 33.

[50] ibid, p. 258.

Summary of the alternative views of "resource"

Consolidating these different discussions on the characteristics of "resources," we can summarize them as in Table 2 below.

Economic and policy view	"anything that requires investment and produces services over time"
Structuration theory	"transformative capacity through which power over material and social world is exercised"
W3C and IETF	"anything that can be pointed with a Universal Resource Identifier (URI)"
IMS IAF	"any digital entity that can be accessed via URI, including competency and education objective definitions; content packages; learning designs; learner information packages; meta-data; question and test packages; vocabularies; resource lists."
SIF	"instructional services; student information services; library systems; grade book; food services; transportation & geographic information services; data analysis and reporting; network account management; human resources & financial management; voice telephony"
Teacher view	"anything that can be used to organize and support learning experiences"
Learner view	"anything that can be mobilized or drawn on to support learning, including prepared course material, notes, information sources, peers, experts, and unintended resources."

Table 2. Alternative definitions of "resource."

Open resources

Based on the discussion above, it is possible to distinguish three quite independent areas where openness makes a difference. One has to do *technical characteristics*, one with *social characteristics*, and the third with *the nature of the resource* itself.

First, there can be technical constraints that limit openness. Lack of interoperability and unavailability of technical specifications are examples here. Broadly interpreted, technical constraints can also include physical constraints, such as geographic distance or timing.

Constraints can also be *social*, for example, institutional or economic. For instance, intellectual property laws can limit access to resources. Although a resource could be available, it can also be so expensive that, in practice, it remains unavailable. This can be simply because license fees are high or because licensing agreements would to be so complicated that they become unmanageable.[51]

[51] Large companies often create large patent portfolios that enable them to cross-license intellectual property with other large companies. Cross-licensing is rarely based on close matching of intellectual property. Sometimes cross-licensing agreements are based on a rough estimate on the thickness of the patent pile. Companies with large patent portfolios can, therefore, often avoid excessive costs of negotiating detailed intellectual property agreements. See, e.g.: Shapiro, C.

Ethical standards related to research and study can also limit access, for example, for privacy reasons. Social constraints form a complex system where balance exists among conflicting tensions, and where, for example, money can buy more access and political power can be used to change institutional constraints.

In this social domain, one may distinguish three different hierarchical levels of "openness." "Openness I" is about access and accessibility. At this first level, one can access the resource. In the terminology of Free Software Foundation, one can "read" the code. "Accessibility" can, however, also relate to individual capabilities. For example, there may be course content freely available but in a language that is incomprehensible for the user, or because some disabilities make the content unusable for some users. Accessibility in the broad sense may be important, for example, for policymakers. A practical criterion for level I openness is whether there is a non-discriminatory opportunity to reach, explore, and study the resource.

"Openness II" is about the right and capability to enjoy the services generated by the resource. In the terminology of Free Software, one can "use" the code. In educational settings, one can, for example, run a computer module. In a broader sense, full use, however, includes the possibility to access all the services generated. If a learner has access to a resource that is open at this second level, one should get full benefits out of its use. For example, if an educational resource is used for acquiring formal educational degrees, if the resource is open at level II, the users should be able to gain formal degrees if they so choose. Well-known OER initiatives, such as the MIT OpenCourseWare initiative, which allows anyone to read courses but which does not support open access to formal degrees, therefore, is open at level I. Whereas at level I openness means, for example, the possibility to read a textbook, at level II it means that the reader can use the book to pass a course. In the specific case of textbooks, this distinction is somewhat tricky, as use and access are fundamentally related for written texts. In other cases, such as executable definitions of pedagogic sequences, the difference is clearer, and with practical consequences.

"Openness III" is about the right and capability to modify, repackage, and add value to the resource. Whereas at level II openness is about free access to services generated by a resource, at level III the user can use the resource itself. At this level, the traditional distinction between the "consumer" and the "producer" becomes blurred. In open source research and innovation studies, the term "user-producer" is frequently used to highlight this blurring of roles. In other contexts, the term "prosumer" has recently gained visibility. Level III openness is, however, also important for teachers and content producers in the traditional model. Copyright regimes usually define "fair use" rights that provide limited openness at level III. As noted above, open source software licenses expand these fair use rights so that modifications and value adding is fully supported.

For policymakers and economists, it is also useful to distinguish qualitatively different types of resources. When technical and social openness exists, some types of resources behave differently from others. One way to describe open resources is to define them as resources that produce service flows that anyone can enjoy, without reducing the enjoyment of others. This definition is related to the concept of public goods. Indeed, this conceptualization underlies historical discussions on open science and intellectual rights.

In economics, a public good is a good that is nonrival, or "joint in supply." Non-rivalness means that consumption of the good by one individual does not reduce the amount of the good available for consumption by others. "Pure" public goods are also non-excludable: goods that, when available, can be enjoyed by all. A public park, public radio broadcasting, law enforcement, and

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(2001) Navigating the patent thicket: cross licenses, patent pools, and standard-setting, available at http://faculty.haas.berkeley.edu/shapiro/thicket.pdf.

unpolluted air are common examples of such a good.[52] Although their name may suggest otherwise, public goods are not necessarily produced by public actors, or using public money.

A large body of economics literature deals with public goods. In general, economists have argued that the market mechanism does not efficiently produce public goods. It is often argued that because public goods are non-excludable, the benefits of public goods “spill over” to consumers who don’t pay for the good.[53] The producer therefore cannot see or appropriate the full value of production. This theoretically leads to a sub-optimal scale of production. In other words, the economy produces less value than it would without public goods. To correct this market failure, policy may be needed.

Education itself could be viewed as an example. The benefits of education spread widely in the society, and there is no single actor who can appropriate all the benefits. From the society’s point of view, public provision or subvention of educational services, therefore, can be justified, also economically.

Economists further define “common pool resources” as resources that are non-excludable, yet rival. For example, in practice the world’s deep sea fish stocks are non-excludable, as it is very difficult to restrict deep sea fishing that occurs in international waters. Yet, fish stocks are also rival, in the sense that extensive fishing reduces them, making it more difficult for others to enjoy the benefits.

Common pool resources have frequently been used to discuss “tragedies of commons.” When benefits can be enjoyed by anyone and no-one can be excluded, but the enjoyment reduces the benefits of others, common resource pools can be rapidly exhausted. The traditional remedy is to make commons private and grant and enforce ownership rights.

Open source software development has often been described as “private production of public goods.”[54] Developers invest their own time and resources in the development, but the results are non-rival and non-exclusive. Different users can use the created software without reducing its value to others, and when software is made available it can create benefits for everyone. From the conventional economic point of view, this is supposed to lead to market failure and sub-optimal scale of production.

Traditional discussions on common pools and tragedies of commons assumed that economic actors are norm-free maximizers of their immediate individual benefits, without capability to cooperate. Empirically, these assumptions are wrong in open source communities. For example, since the foundation of the GNU project in the early 1980s, the explicit goal of many open source projects has been to collaborate in the production of common goods. History shows that they have successfully done exactly that.[55]

Open source resources can, however, also be characterized as a mirror image of common pool resources. Common pool resources have the specific characteristic that they are subtractable. When

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[52] Cf. Snidal, D. (1979) Public Goods, Property Rights, and Political Organizations. *International Studies Quarterly*, Vol. 23, No. 4 (Dec., 1979), pp. 532-566.

[53] This lead to the so-called ”free-rider problem.” See, e.g., Hardin, R. (2003) The free rider problem. Standford Encyclopedia of Philosophy. Available at: http://plato.stanford.edu/entries/free-rider/.

[54] Cf. O'Mahony, S. (2003). Guarding the commons: how community managed software projects protect their work. *Research Policy,* **32** *(7),* pp.1179-98.

[55] The open source developers’ apparent altruism can, of course, be explained away by explaining altruism, itself, as a benefit-maximizing strategy. For example, Lerner and Tirole have highlighted the potential importance of delayed payoffs, such as enhanced career opportunities, and ego gratification generated by peer recognition. Cf. Lerner, J., & Tirole, J. (2000). The simple economics of open source. National Bureau of Economic Research. NBER Working Paper No. 7600.

someone uses the pool, the value of the pool diminishes. This, in fact, is a common feature in real life if the resources are not renewable or if their renewal occurs slower than their depletion. Open source is from this point of view an interesting economic resource. As the future value of the system depends on the amount of developers and the availability of complementary products, an open source pool may become more valuable when more people use it. In this sense, open source can be described as an *open fountain of goods*.[56] Many digital products can be copied without losing the original copy. When open source code is copied, the value of the original often increases.

Traditional economic theories have difficulties in modeling such phenomena. The basic historical problem for classical economists was the question how to maximize the consumption of scarce goods. This was a relevant question in a world where the lack of consumption possibilities was a daily challenge and where people lived in poverty and hunger. Open source development, in contrast, is a social process that creates goods where they did not exist before. In a “fountain of goods” model, the limiting factor for growth is not the decreasing marginal benefit and increasing cost; instead, it can be found from the dynamics of social change and development of human competencies and knowledge that are needed to realize the emerging opportunities.[57]

From an economic point of view, we can therefore distinguish four different types of resources. One is a private resource. To enjoy the services generated by a private resource, one has to pay the value they produce. Either the owner pays for the ownership to enjoy the generated services, or an outsider consumer pays to the owner. The second resource type is a common pool. In this case, no-one pays for the services, except perhaps down the line, when the resource becomes unavailable and has to be substituted. The third resource type is a public good. Consumers can enjoy the services in this case without diminishing the enjoyment of others.

The fourth type of resource was called an open fountain. When the use of such a resource increases, the resource does not diminish. Instead, the value of the resource increase with increased use. Such resources do not make much sense in conventional economic theory. In practice, open source software and –perhaps most importantly– public scientific knowledge are examples of such resources.

The idea that public science is fundamentally a different “good” than traditional goods has been well understood for many centuries. In fact, historically intellectual property regimes have been structured to balance two sometimes contradictory requirements: the effective generation of knowledge available for public use, and facilitation of the generation of that knowledge, in the first place.

Economists normally define pure public goods as non-rival and non-excludable. An important method of creating private goods from public goods is to make them excludable. In the context of educational resources, this often means the enforcement of copyrights. To understand the impact of copyrights on educational resources, it is useful to recall the historical objectives of copyrights. In fact, the first modern copyright law was aptly introduced as “An Act for the Encouragement of Learning.”

Knowledge as a public good

Historically, the original goals of the copyright rules were to limit competition among printers and to control the content of texts that became available. Printing rights were essentially monopoly

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[56] Tuomi, I.(2005) The future of open source. in Wynants, M. & J. Cornelis (eds.) *How Open is the Future? Economic, Social and Cultural Scenarios Inspired by Free and Open-Source Software*, VUB Brussels University Press, Brussels, 2005, p. 444.

[57] Tuomi, I. (2002) *Networks of Innovation*. Oxford, Oxford University Press.

rights, granted as favours to individual printers and as a means to control the distribution of texts. The first full expression of these ideas was the 1662 Licensing Act of England.[58]

The Licensing Act expired in 1692, and the House of Commons refused to renew the law, arguing that the printers had abused their monopoly. To address the chaotic situation in the printing business, the printers petitioned Parliament for relief, and the Parliament responded by enacting the Statute of Anne in 1710. This act is commonly viewed as the foundation for modern copyrights. It stated that the copyright belonged to the author of the work, or to the assignee of the author, and that copyrights were granted only for a limited time, after which the works became freely available for the public.

The copyright law granted limited monopolies because it was perceived that cheap and uncontrolled copying was leading to a situation where rampant piracy would make it impossible for authors and printers to make a profitable business. The Statute noted that it was needed as frequent copying without the consent of authors or proprietors had lead to their "great detriment, and too often to the ruin of them and their families." On the other hand, the monopoly was limited, as monopolies were considered to be harmful. The Statute also included a clause that enabled anyone to make a complaint if the price of the book seemed to be artificially high.

The concept of *public domain* was implicitly established in the Statute of Anne. The Statute was introduced as "An Act for the Encouragement of Learning," and it tried to balance two elements that were supposed to lead to Learning. It gave a limited monopoly to the authors so that they would have an incentive to create original new knowledge, "for the encouragement of learned men to compose and write useful books," but it also required that after the copyright term expired, the work would become freely available. The copyright term was fixed at fourteen years, which could be extended by another fourteen years if the author was alive when the original copyright expired. The Statute did not imply any restrictions beyond copying. Once the book was bought, the copyright owner did not have any control of its use.

Since the Statute of Anne, the scope of intellectual property rights has expanded considerably. In this process, the public domain has gradually diminished. The expansion has been particularly rapid in the last three decades. Scientific and technological knowledge is now commonly covered through patents and copyrights that extend to photo-lithographic mask works of microchips, databases, genetic material, computer software, and business models, for example. As Paul David notes:

> "During the past two decades a renewal of enthusiasm for expanding and strengthening private property rights over information has given rise to a rather paradoxical situation. Technological conditions resulting from the convergent progress in digital computing and computer-mediated telecommunications have greatly reduced the costs of data capture and transmission, as well as of information processing, storage and retrieval. These developments are working to give individuals – and especially researchers – unprecedentedly rapid and unfettered access to new knowledge. At the same time, and for reasons that are not entirely independent, the proliferation of intellectual property rights and measures to protect these is tending to inhibit access to such information in areas (basic research in general, and most

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[58] Cf., Tuomi, I. (2004) Knowledge sharing and the idea of public domain. Paper prepared for the UNESCO 21st Century Dialogues, "Building World Knowledge Societies" Seoul, Republic of Korea, July 26-27, 2004. Available at: http://www.meaningprocessing.com/personalPages/tuomi/articles/KnowledgeSharingAndTheIdeaOfPublicDomain.pdf

> strikingly in the life sciences, and computer software) where new knowledge had remained largely in the public domain."[59]

According to David, a good bit of intellectual ingenuity and entrepreneurial energy is now being directed towards the goal of neutralizing the benefits of information technology and for creating artificial scarcities in fields where abundance naturally prevails. David argues that this creates two types of inefficiency:

> "The first-order effect is the curtailment of the use of the information, or the increased cost of using it to produce conventional commodities and services, and hence the loss of utility derived from such products by consumers. A second round of inefficiency is incurred by the inhibition of further research, which otherwise would be the source of more public goods in the form of new knowledge."[60]

David further points out that, to understand the full irony of this situation, one simply needs to note that knowledge is inherently a non-rival good. In this view, knowledge is, indeed, a public good, and the incentives that are created by "privatizing" knowledge actually arise from artificial scarcities that are of no particular social value. One can therefore also turn around the traditional challenge of "tragedy of commons," and ask what the costs of granting ownership to knowledge are, and whether artificial scarcities really create value in a knowledge-based economy.

From policymaker's point of view, if knowledge resources are inherently public goods, or perhaps even open fountains that grow in value when they are used, "openness" in its different forms makes abundant sense. The balance between public benefits, and the need to "encourage learned men to compose and write useful books" and to avoid ruining them and their families, still has to found. In the modern world, learned men and women are encouraged in many ways and for many reasons. Many of these were beyond imagination when the Statute of Anne was originally drafted. In the knowledge-based economy, the copying of works does not necessarily lead to the ruin of the authors. Empirical evidence and many examples on the internet show that both the authors and the society can, at least in some cases, greatly benefit from free copying. But –as successful open source software businesses have show– also new business models may be necessary. This is only natural if the emerging economy is fundamentally driven by value creation and innovation, instead of allocation of scarce consumption opportunities.

Defining OER

A definition of a concept depends on its use. The concept of colour means different things when used in a community of painters, physicists, movie directors, poets, or neurophysiologists. Different user groups have different practical interpretations of world and their meanings, and these form complex interrelated systems that makes communication possible. Even when there is a consensus about the proper uses of the concept within a specific community of users, things that look similar, can look very different, depending on categorizations and the level of abstraction we decide to use. It is therefore a challenging task to find a generic definition for open educational resources.

One possibility is to ground conceptual meaning on the actual use of the term. We can characterize existing open educational resource projects and categorize and sort the various initiatives into

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[59] David, P. A. (2003) The Economic Logic of "Open Science" and the Balance between Private Property Rights and the Public Domain in Scientific Data and Information: A Primer. SIEPR Discussion Paper No. 02-30. Available at: http://siepr.stanford.edu/Papers/discussion_papers_index.html.

[60] David, P. A. (2003) ibid.

bundles that make sense among practitioners. Using such a "bottom-up" approach, we can map OER projects and initiatives as in Figure 5. The figure includes projects that are described in the Appendix, and also some well-known projects that are not explicitly described due to space limitations.

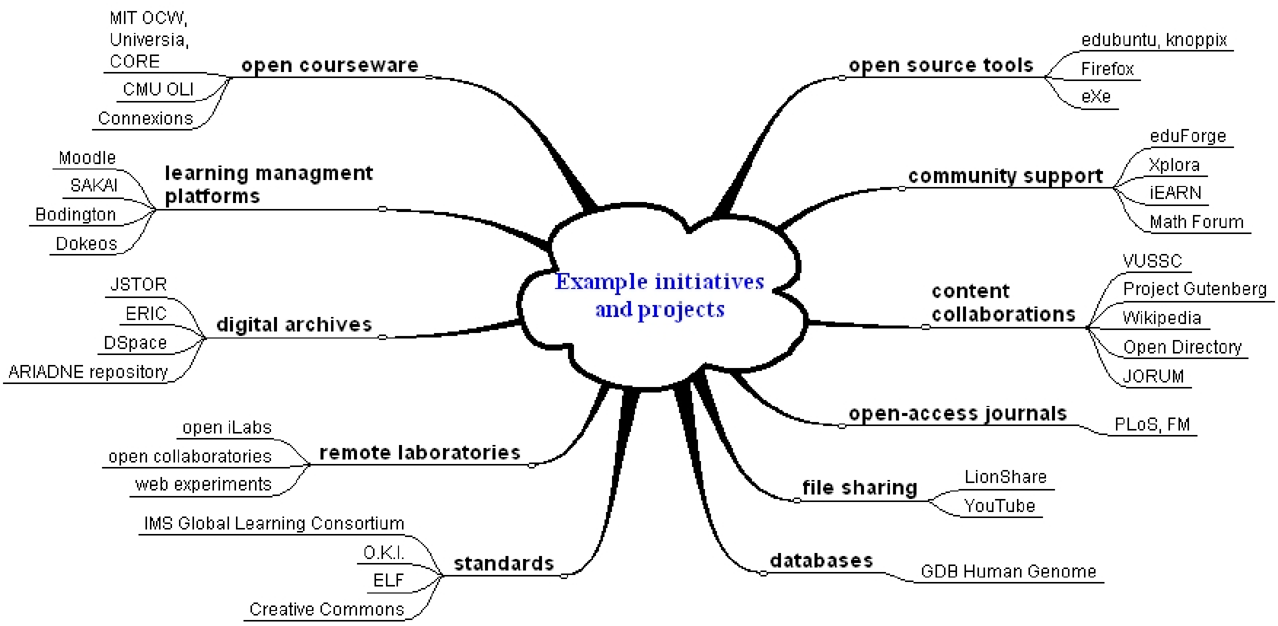

Figure 5. Initiatives and projects.

The UNESCO definition

According to the UNESCO definition, open educational resources are:

> "The open provision of educational resources, enabled by information and communication technologies, for consultation, use and adaptation by a community of users for non-commercial purposes." [61]

Comparing the different clusters in Figure 5 with the definition proposed by UNESCO, we can see that the UNESCO definition covers quite well the projects and initiatives discussed in the Appendix. The UNESCO requirement that resources are provided for non-commercial purposes is, however, somewhat unclear. Open source software development projects have been based on a number of open source business models. These can, for example, provide commercial services that support open source implementations, generate revenue from dual licensing that separates non-commercial and commercial use, or which use banner advertisement to fund the project. The Open Source Initiative, itself, requires that open source licenses do not discriminate against commercial use,[62] and open source projects, therefore, can not be open educational resource projects according to this definition. Also the Free Software Foundation licenses allow software to be used for commercial purposes. The existence of business firms such as Red Hat, which packages and distributes GNU/Linux, shows that open software can co-exist with commercial provision, and that the users can deploy a large variety of commercial and non-commercial models. Indeed, the

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[61] http://unesdoc.unesco.org/images/0012/001285/128515e.pdf.

[62] http://www.opensource.org/.

question of how commercial activities can be linked with open source projects is often seen as a key issue in developing sustainable models for open source development. It therefore appears that the UNESCO definition unnecessarily requires that the resources are provided for non-commercial purposes.

Strictly speaking, the UNESCO definition is also tautological, as it defines open educational resources as “the open provision of educational resources.” The definition thus leaves undefined the question what is a resource, and what is educational. As was discussed above and summarized in Table 2, there are many views on the pertinent characteristics of resources, and more specifically, on the characteristics of open resources. If “open provision” means open access, practical implications are different from those that follow from an interpretation that requires rights for reuse, modification and value adding. “Open provision” does not easily allow us to detail those technical and social constraints that regulate access and use. In practice, the capability of users to grasp such openly provided resources is of great economic and policy relevance.[63] From a policy point of view, the possibility that different types of resources may have are fundamentally different innovation and developmental logics, also requires that we can say something about the nature of these different types of resources, and categorize them in a useful way. As suggested above, openness is not only about open provision. Instead, some resources can be characterized as inherently public goods or open fountains that can produce social benefits. Many OER projects have been motivated by the ideals of open science, where not only the provision of scientific outputs but the system that produced the outputs is open. In the UNESCO definition, it remains ambiguous whether “open provision” means open availability of outputs or open process of generating the outputs. In open source software projects, the latter has been a key to fast development.

The UNESCO definition also requires that the resources are openly provided for a community of users. This includes, for example, national initiatives, where access to resources is limited to internet addresses registered within the specific country. The definition also includes resources that can be accesses only by students registered in a specific school or university, or who are employees of a specific organization. As sociologists could point out, openness occurs within social and material structures. If a computer program would read the UNESCO definition, it might, for example, come up with the idea that educational resources provided exclusively to members of a gated community, to members of a specific clan, or to a group of people who pay yearly fees for a club membership, are by definition, open educational resources.

Human readers, obviously, are able to interpret definitions in ways that make sense. Accurate definitions rarely exist when stakeholders are many. With the above caveats, the UNESCO definition provides a good starting point for discussions on open educational resources.

OER as a non-rival good

One common reason to include “non-commercial use” as a criterion is the attempt to avoid disturbing market competition. By definition, non-commercial activities are outside markets. Obviously, the idea that market competition will not be disturbed by non-commercial use is a tricky one, as non-commercial typically either means that no commercial players have current interest in the activities, or that the society has structured the markets so that some things are not provided by commercial actors. As was noted above, intellectual property rights, for example, were originally designed to structure imperfect knowledge markets, so that public interest and private incentives are

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[63] The question of how to link rights, freedoms, capabilities and development has been discussed in great detail, for example, in Sen, A. (2000). *Development as Freedom.* New York: Anchor Books.

balanced. Knowledge markets do not create perfect competitive markets, and it does not make sense to require that they should operate under such a counterfactual market. One can, for example, ask whether the definition of open educational resources should differentiate among resources that exist under different market conditions, or which produce services that are consumed in qualitatively different markets.

As was noted above, a useful distinction can be made between the provision of traditional goods, public goods, common pool resources, and services that originate in "open fountains of goods." Traditional goods are rival: when someone consumes the good, it cannot be consumed by others. Public goods, in contrast, are non-rival. When someone consumes a good, other can keep on enjoying it. Digital products and knowledge are in many cases such non-rival goods.

Common pool resources are resources that produce services that are non-excludable, but rival. When someone is able to enjoy them, everyone is able to enjoy them. When the benefits are enjoyed by some, the value of the pool to others, however, decreases. An open library is an example here. When a sufficient number of lenders have reserved a book, the book will for practical purposes become unavailable. The public library, in fact, represents an interesting boundary case between public goods and common pool resources. If the lender is able to wait for the book, the library becomes a public good.

Digital resources have a different dynamic here. First, they tend to common pools towards public goods. Copies of a digital book can be borrowed as many times as the lenders want if restrictions such as digital rights management systems do not make this impossible. Second, in the specific case where the resources increase in value when they are used more, the result is a resource that can be characterized as an open fountain of goods. Open source software projects and, for example, Wikipedia can be described using this category of non-traditional goods.

Five points of view

The distinction between traditional goods, public goods, common pools, and fountains is important because it leads to different development and economic policies. Open educational resources, for example, could be defined as educational resources that are economically approximately public goods. A future-proof definition would take into account the impact of digitalization and emerging technologies. For the specific case where such public goods are also fountains of goods, for example peer-produced digital resources, public promotion could make ample economic and social sense. The different views on open educational resources are depicted in Figure 6.

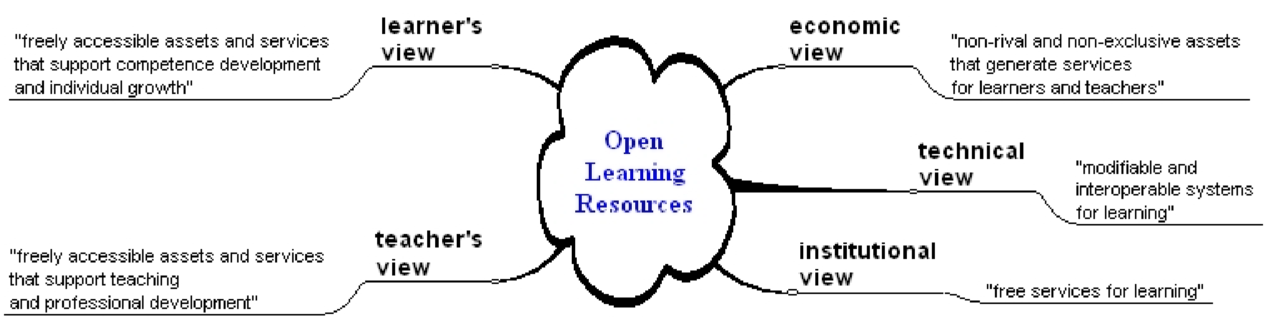

Figure 6. Alternative views on open educational resources.

Summarizing the discussions above, we may then develop definition that encompasses different OER initiatives and integrates the different points of view.

OER defined: the concept of learning, the levels of openness, and open resources

We adopt a pedagogic view which sees the aim of education as both individual and social development. Learning is not only about moving knowledge into the learners mind, but it is about developing capabilities to think and act. Learning can be innovative and it can create knowledge that did not exist before. We include an "emancipatory" objective of learning that aims at human development. Furthermore, we assume that the effects of learning are eventually expressed in the social environment, and that social learning, itself, is important for development. Learning resources can then be defined in the following functional way, which focuses on their effect, and which abstracts from any particular stakeholder point of view:

> Learning resources are assets that generate services that enable the development of individual or social capabilities for understanding and acting.

As was discussed above, openness can exist in many different domains and levels. We use the three hierarchical levels introduced above, and add the requirement that the resource itself can be characterized as a non-rival good. Although there may be open educational resources where the resource itself is rival or non-renewable, we make the assumption that non-rival resources are qualitatively different, and that the importance of this difference will be dominant in the emerging knowledge society and economy. This, essentially, is a prescriptive argument that says: "For the time being, forget the other types of open resources."

One should note that existing OER initiatives fall on the different layers in the presented hierarchy. The "most complete" openness, at level III, can be found in open source development projects that produce educational resources. Many important initiatives, however, only provide openness on the first or second level. The hierarchy, therefore, is a descriptive characterization of different types of openness, and not a normative claim that initiatives on the lower levels are not open enough. Although, strictly speaking, many open courseware initiatives and open access publications are open only at level I, the fact that access to text in practice implies the possibility to use the content for learning, positions them somewhere between level I and II. Assuming that the only service that a digital text resource can provide is the benefits that flow from reading it, levels I and II become overlapping. For other types of resources, the overlap is smaller. Furthermore, as was discussed above, resources that are open at level II should provide access to all services that the resource generates, including, for example, the possibility to use the text for study that aims at formal certificates. The three levels of open educational resources are defined as:

> Open resources are sources of services that do not diminish their capability to produce services when enjoyed and which
>
> 1) provide non-discriminatory access to information and knowledge about the resource (level I openness)
> 2) the services of which can be enjoyed by anyone with sufficient non-discriminatory capabilities (level II openness)
> 3) can be contributed to (level III openness)

At level three, one needs, however, to specify the conditions under which contributions can be made. Contribution implies improvement. What counts as improvement is a difficult question, where social institutions and structures of signification, domination and legitimation come in to play, to use the terminology of Giddens. Here we borrow the Mertonian norms of open science, and require that contributions would also count as "academic" contributions in the Mertonian sense.

In the Mertonian view, academic science is based on five basic norms.[64] As science proceeds by accumulating and revising knowledge, disclosure of scientific results and methods is critical for the success of the scientific endeavour. Results of science should therefore be common property of the scientific community. Second, scientific process should be universal, in the sense that anyone with sufficient competences can participate, regardless of nationality, cultural differences or personal characteristics. Third, as scientific knowledge is characterized and made "objective" by its communally shared acceptance, scientists should present results in a way that does not explicitly reflect personal interests or preferences. In other words, the scientific results should not depend on who created them. Fourth, to advance knowledge, research contributions should be original. And, fifth, all claims should be subject to organized critical scrutiny. These five principles of "communalism," "universality," "disinterestedness," "originality," and "scepticism" have often been summarized by the acronym CUDOS.[65] Openness at level III means that anyone can contribute to the resource, and that contributions can be rejected only by criteria that are compatible with the norms of academic science.

Open educational resources are open resources that are also resources for learning. Combining the previous characterizations we can then define open educational resources as:

> Open educational resources are accumulated assets that
>
> 1) enable development of individual or social capabilities for understanding and acting
>
> and
>
> 2) can be enjoyed without restricting the possibilities of others to enjoy them
>
> and which either
>
> 3) provide non-discriminatory access to information and knowledge about the resource
> 4) generate services that can be enjoyed by anyone with sufficient non-discriminatory capabilities
> 5) can be contributed to by anyone, without restrictions that exceed the norms of open science

Conclusion

In this paper, we discussed the motivation and drivers of the open educational resource initiatives. We discussed different types of openness in technical and social systems, and explored the characteristics of different types of resources. Using these as a background, and complementing the discussion with a survey of existing open educational resource initiatives, described in the Appendix, we developed a theoretically grounded definition of open educational resources. As was noted, practical definitions require that we define the purposes for which the definition will be used

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[64] Merton, R.K. (1942) Science and technology in a democratic order. *Journal of Legal and Political Sociology*, 1, 115-26.

[65] Merton alludes here to the Greek word *kudos*, or magical glory.

and the community that uses the concept. A more generalized definition, however, is useful when different actors have to work together. This is particularly the case with open educational resources. They have important social consequences and benefits, and they are important for the development of individual capabilities. In the knowledge society, learning and knowledge creation will be at the core of social and economic change. Information networks will connect actors together and both enable and demand new forms of collaboration. The concept of open educational resources is already widely used in many different contexts, ranging from educational to technical, political, economic, and legal. A shared definition that integrates the different perspectives and interests is important and useful if it allows collaboration of the different actors and, eventually, joint initiatives that realize the emerging potential of open educational resources.

Appendix: Example initiatives used to derive the definition

Project Gutenberg

Project Gutenberg was set up in 1971 by Michael Hart. It has now over 19,000 free ebooks, whose copyrights have expired and which therefore are in the public domain. Project Gutenberg serves 2 million ebooks to readers each month.[66] It also offers both automatic text-to-speech translated and human-read audio books, and digitized music sheets.

Project Gutenberg is a volunteer community effort. To remove errors produced by optical character recognition software, and to create high-quality ebooks, volunteers can register as Distributed Proofreaders[67] to proofread one scanned page at time. When a proofreader elects to proofread a page of a particular book, the text and image file are displayed on a single web page. This allows the page text to be easily reviewed and compared to the image file, thus assisting the proofreading of the page text. The edited text is then submitted back to the site via the same web page that it was edited on. A second proofreader is then presented with the work of the first proofreader and the page image. Once they have verified the work of the first proofreader and corrected any additional errors the page text is again submitted back to the site. The book then progresses through two formatting rounds using the same web interface to produce a finished ebook.

The proofreaders can read as many or as few pages as they want. The informal goal is that each volunteer reads one page a day. The distributed proofreading system had over 3,000 active users during September 2006, and during its six years of existence the service has produced over 9,000 ebooks.

ERIC

ERIC provides free access to more than 1.2 million bibliographic records of journal articles and other education-related materials and, if available, includes links to full text. ERIC is sponsored by the U.S. Department of Education, Institute of Education Sciences (IES).[68]

ERIC - the Education Resources Information Center - is an internet-based digital library of education research and information sponsored by the Institute of Education Sciences (IES) of the U.S. Department of Education. ERIC provides access to bibliographic records of journal and non-journal literature indexed from 1966 to the present. ERIC also contains a growing collection of full-text materials in Adobe PDF format.

Currently, more than 650 journals are indexed in ERIC. About 500 of these journals are indexed comprehensively — every article in each issue is included in ERIC. A small number (about 150) are indexed selectively — only those articles that are education-related are selected for indexing.

In addition, contributors have given ERIC permission to display more than 100,000 full-text materials in PDF format - at no charge. These materials are generally part of the recent “grey literature” such as conference papers and reports, rather than journal articles and books.

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[66] http://www.gutenberg.org/wiki/Main_Page.

[67] http://www.pgdp.net/c/default.php.

[68] http://www.eric.ed.gov/ERICWebPortal/Home.portal

Open Access Journals

In recent years, the number of open access journals has increased rapidly around the globe. The Directory of Open Access Journals lists now over 2,400 free, full text, quality controlled scientific and scholarly journals.[69]

One example is the the Public Library of Science (PLoS). PLoS is a nonprofit organization of scientists and physicians committed to making the world's scientific and medical literature a public resource.[70] It was founded in October 2000. Under the open access model, PLoS journals are immediately available online, with no charges for access and no restrictions on subsequent redistribution or use, as long as the author(s) and source are cited, as specified by the Creative Commons Attribution License.

PLoS charges authors a fair price that reflects the actual cost of publication. A "no questions asked" fee waiver exists for authors who do not have funds to cover publication fees.

PLoS publishes now seven open access journals.

Another example is First Monday, Internet–only, peer–review journal about the Internet.[71] First Monday was launched in 1996, and it has published some key articles on open source, digital libraries and open learning. First Monday has a very fast review process, and articles are often published within weeks of their submission.

The theme of the second First Monday conference, organized in May 2006 to celebrate the tenth birthday of First Monday, was *Openness: Code, science and content.* Papers from the conference have been published in the June and July 2006 issues.

Moodle

Moodle is an open source e-learning platform, a software package designed to help educators easily create quality online courses. It is also characterized as a Course Management System (CMS) or Virtual Learning Environment (VLE). Moodle has now a very large user base. In September 2006, there were 16,174 registered Moodle sites in over 160 countries, speaking over 75 languages. Of these sites, 180 registered sites had over 5,000 users. In total, the registered sites had over 6 million students and 1 million teachers, and about 600,000 courses. On average, over 1,000 copies of the Moodle software was downloaded daily in 2006.[72]

The design and development of Moodle is guided by a social constructionist pedagogy. It therefore supports collaboration, activity-based learning, and critical reflection. This defines the teacher's role as an influencer and role model of class culture, by engaging with the students in a personal way through discussions and activities, to guide students towards the learning objectives of the class.

Bodington

Bodington is a free, open-source VLE. Its main features include: log books, questionnaires, assignment submission, etc. The structures provided use the metaphor of a campus with buildings, floors and rooms.[73] Users place materials, questionnaires and other components in a specific room

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[69] http://www.doaj.org/. For major events and initiatives in the open access movement, see Peter Suber's "Timeline of the Open Access Movement" at http://www.earlham.edu/~peters/fos/timeline.htm.

[70] http://www.plos.org/.

[71] http://firstmonday.org/.

[72] http://moodle.org/.

[73] http://www.bodington.org/index.html

on a floor of a building on the virtual campus instead of organising it into faculties, courses, etc. The idea is to make information easy to find by being able to direct students and staff to a specific building and room instead of giving a web address. It is now the third most widely used VLE in the U.K., roughly as popular as Moodle.

eXe

The eXe project is developing an off-line authoring environment to assist teachers and academics in the publishing of web content without the need to become proficient in HTML or XML markup.[74] This open source software project is funded by a grant from the Tertiary Education Commission of New Zealand. eXe supports the definition and modification of pedagogical models through instructional devices, or iDevices. iDevices can be used to package reusable processes or instructional templates. The project is still in early development. The release 0.18 in September 2006 added support for math iDevice and multimedia iDevice, as well as support for Czech, Tagalog, Twi and Ewe languages.

LionShare

LionShare is a file-sharing architecture that facilitates among institutions around the world. LionShare is based on the Gnutella Peer-to-Peer file-sharing system, to which it adds trust and access control mechanisms. It provides tools for the exchange of academic, personal and work-related materials on an officially sanctioned and secure P2P network among participating groups and institutions around the world.

The system allows an authenticated P2P network user at one institution to search and access resources at other participating institutions. For example, members of a project in one class can share content with members of another class located in a different country, without making the content visible to the rest of the world. LionShare provides tools to organize, manage and retrieve digital resources; tools for gathering and sharing information among peers; controlled access of shared materials such as digital images, audio, video and text; plus collaborative tools for facilitating joint efforts among peer institutions.[75] The P2P architecture allows the exchange of extremely large files that could not easily be transferred using centralized repositories. LionShare is developed under the GPL open source license.

OKI

The Open Knowledge Initiative (O.K.I) develops and promotes specifications that describe how the components of a software environment communicate with each other and with other enterprise systems.[76] O.K.I. has developed and published the Open Service Interface Definitions (OSIDs), whose design has been informed by a broad architectural view, where software components access each other as “services.” The OSIDs provide general software contracts between service consumers and service providers. This enables applications to be constructed independently of any particular service environment, and eases integration. The OSIDs enable choice of end-user tools by providing plugin interoperability.

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[74] http://exelearning.org/.

[75] http://lionshare.its.psu.edu/news/faq

[76] http://okicommunity.mit.edu/

Eduforge

Eduforge is an open access environment designed for the sharing of ideas, research outcomes, open content and open source software for education. The users can use community resources or start their own project spaces. Eduforge is fashioned after SourceForge.net, the largest open source development web site, which hosts over 130,000 open source projects.[77]

Eduforge hosted 131 projects and it had some 1,500 registered users in September 2006. The project types are shown in Table 3. The largest set of projects deals with learning management systems, with 34 projects, followed by projects in communication (29 projects) and communities of practice and collaboration (22 projects). In many cases, Edufoge simply links to actual project sites and does not store actual project content, for example project source code.

Accessibility (6 projects)
Authoring (19 projects)
Communication (29 projects)
Community of Practice & Collaboration (22 projects)
ePortfolios (4 projects)
Games & Simulations (8 projects)
Intranet (7 projects)
Learning Design and Pedagogy (18 projects)
Learning Management System (LMS) (34 projects)
Learning Object Repository (12 projects)
Multimedia (4 projects)
Professional Development (9 projects)
Quiz Engines, Survey Tools (3 projects)
Research (16 projects)
Standards (13 projects)
Web Services (14 projects)

Table 3. Project types in eduForge, September 2006.

DSpace

The DSpace digital repository system captures, stores, indexes, preserves, and distributes digital research material. Research institutions worldwide use DSpace as an institutional repository, a learning object repository, for records management, for publishing articles, preprints, technical reports, eTheses, and more. Dspace is freely available, as an open source platform.[78] There are now about 130 institutions around the world that use Dspace.

Sakai

Sakai is an online Collaboration and Learning Environment, originally developed by merging learning management systems between Indiana University, the University of Michigan, Stanford, and MIT. The project is supported by a large grant by the Mellon Foundation.

The users of Sakai can deploy it to support teaching and learning, ad hoc group collaboration, support for portfolios and research collaboration. Sakai is a set of software tools designed to help

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[77] http://eduforge.org/

[78] http://www.dspace.org/

instructors, researchers and students create websites on the web. For coursework, Sakai provides features to supplement and enhance teaching and learning. For collaboration, Sakai has tools to help organize communication and collaborative work on campus and around the world.[79]

The Sakai software includes many of the features common to Course Management Systems, including document distribution, a gradebook, discussion, live chat, assignment uploads, and online testing. Sakai relies on standards such as the O.K.I. repository open service interface definition, which itself is maintained through the IMS Global Learning Consortium. Using standard interface specifications, Sakai is able to function independent of specific local software implementations. Figure 7 shows, for example, how Sakai can use the O.K.I. / IMS repository interface to connect to a number of underlying repositories.

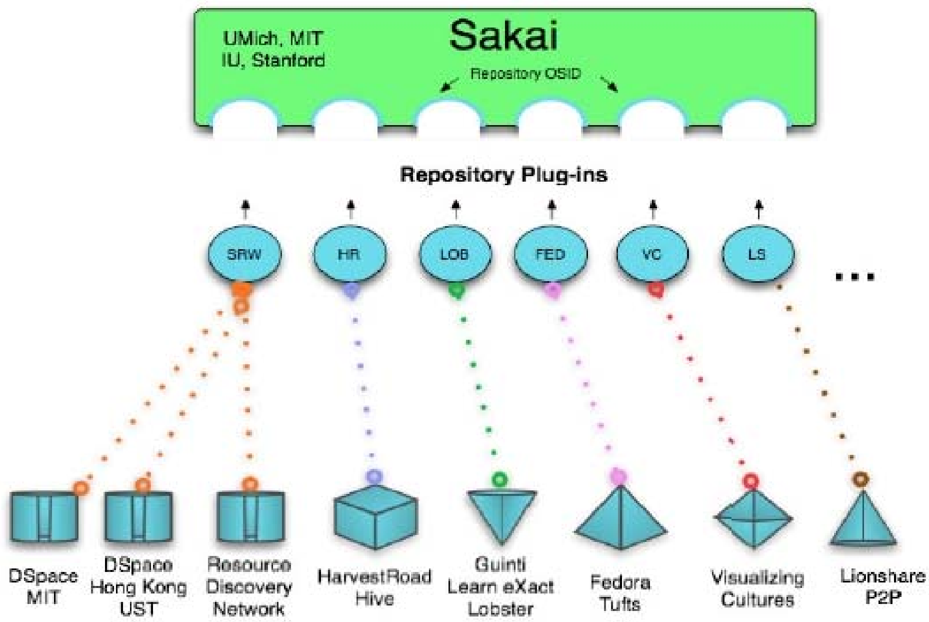

Figure 7. Sakai repository interface.[80]

MIT OCW

MIT Open Courseware initiative (MIT OCW) is a large-scale, Web-based publication of the educational materials from the MIT faculty's courses.[81] This initiative enables the open sharing of the MIT faculty's teaching materials with educators, enrolled students, and self-learners around the world. The resources are available without registration. MIT OCW provides users with open access to the syllabi, lecture notes, course calendars, problem sets and solutions, exams, reading lists, and a selection of video lectures. As on May 2006, MIT OCW had published 1,400 MIT courses representing 34 departments and all five of MIT's schools.

Several initiatives have been launched to translate the MIT OCW courses to different languages and to contribute new courses. A large adopter has been the Universia network of over 985 Spanish and Portuguese speaking universities. Universia operates in Spain, Chile, Brazil, Puerto Rico, Peru,

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[79] http://www.sakaiproject.org/

[80] MIT (2005) The O.K.I. Repository OSID and SAKAI. http://okiproject.org/filemgmt-data/files/CaseStudy-Sakai-4pgs.pdf

[81] http://ocw.mit.edu

Venezuela, Argentina, Mexico, Portugal, Colombia and Uruguay. In addition to translated MIT OCW courses, it provides basic internet services, including chat, e-mail, web forums, and weblogs.[82] Another important is the Chinese Open Resources for Education (CORE).[83] Its mission is to promote closer interaction and open sharing of educational resources between Chinese and international universities, which CORE envisions as the future of world education. Its objective is to introduce advanced courseware from MIT and other top-ranked universities around the world by using the latest information technology, teaching methodologies, instructional content, and other resources to improve educational quality in China. At the same time, CORE will share advanced Chinese courseware and other quality resources with universities internationally.

The MIT OCW initiative has been extremely visible around the world and a large number of related initiatives have been launched. The OpenCourseWare Consortium is a collaboration of more than 100 higher education institutions and associated organizations from around the world creating a broad and deep body of open educational content using a shared model. The mission of the OpenCourseWare Consortium is to advance education and empower people worldwide through opencourseware.[84] In order to participate in Consortium activities, institutions must have committed to publishing, under the institution's name, materials from at least 10 courses in a format that meets the agreed-upon definition of an opencourseware. Organizations that do not publish their own content but whose activities further Consortium goals—such as translation and distribution affiliates—also participate in Consortium activities.

Connexions

The Connexions open educational resource platform at the Rice University aims at publishing "knowledge chunks" or modules that can be combined and linked to produce custom courses. Connexions is not limited to the content produced within its host institution; instead, anyone can submit contributions that will be peer-reviewed after publication. Connexions is internationally focused, interdisciplinary, and grassroots organized. There are now 3531 modules and 182 courses developed by a worldwide community of authors in fields ranging from computer science to music and from mathematics to biodiversity. Most modules are in English, but there are also modules written in Chinese, Italian, Japanese, Portuguese, Spanish, and Thai.[85]

iEARN

iEARN (International Education and Resource Network) is a non-profit organization made up of over 20,000 schools in more than 115 countries. iEARN empowers teachers and young people to work together online using the Internet and other new communications technologies. Over 1,000,000 students each day are engaged in collaborative project work worldwide.[86]

VUSSC

Established in 2006 through a collaboration between education ministers of the Commonwealth Heads of Government and the Commonwealth of Learning (COL), the Virtual University for Small States of the Commonwealth (VUSSC) is an effort to foster a collaborative network for educators in small states in various regions around the world. VUSSC uses a wiki platform to bring together

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82 http://www.universia.net/

83 http://www.core.org.cn/en/index.htm

84 http://ocwconsortium.org/about/index.shtml

85 http://cnx.org/

86 http://www.iearn.org/about/index.html

"learning content developers" who are committed to the collaborative development and sharing of free content resources for education.[87] The project was launched in August 2006 with a "boot camp," with participants from Antigua & Barbuda, Barbados, Belize, Botswana, Comores, Cyprus, Dominica, The Gambia, Jamaica, Lesotho, Maldives, Malta, Mauritius, Namibia, Papua New Guinea, Samoa, Seychelles, St. Kitts & Nevis, St. Vincent & the Grenadines, Swaziland, Tonga, Trinidad & Tobago, Tuvalu and Vanuatu.

Xplora

Xplora is the European gateway to science education. It is aimed at teachers, pupils, scientists, science communicators and science educators. It is operated by European Schoolnet –a network of 28 European Ministries of Education. Users can read science education news, pedagogical tips, ideas for teachers, search the database of websites and digital learning resources for science education, create online communities and join online discussions, get insight into innovative practical science approaches and projects, and obtain guidance on freely available Open Source tools for science education.[88]

An example activity in Xplora is "web experiments." Web experiments are practical science procedures controlled at a distance, using a web site. The experimental equipment can be located in university, science museum or other location. By using web experiments, pupils can take part in experiments not permitted in school and apply database techniques for analysing and storing results of an experiment, while teachers and technicians are supported by external staff.

edubuntu

Edubuntu is a Linux distribution targeted for schools and other educational environments. Edubuntu is designed for a teacher or network administrator to be able to setup a complete classroom quickly and easily. It includes open source tools that are useful in educational settings, including the Xfig vector graphics program, the Gimp image manipulation program, teaching and learning applications and Junior school resources.

LRC

The online Learning Resource Catalogue (LRC) Project has been part of an international consortium for several years and currently includes 25 institutions worldwide. an academic network whereby members can identify and share reusable learning objects as well as collaborate in a number of ways. The LRC3 therefore includes a "distributed repository" in that the objects may reside in many different places yet can be located through the catalogue which uses IMS-based learning object metadata. The LRC3 also includes uploading of resources for people who wish to avail themselves of a central repository for their learning objects. [89]

CORDRA and ADL Registy

Content Object Repository Discovery and Registration Architecture (CORDRA) is an open, standards-based model for how to design and implement software systems for the purposes of discovery, sharing and reuse of learning content through the establishment of interoperable

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[87] http://www.wikieducator.org/VUSSC.

[88] http://www.xplora.org/ww/en/pub/xplora/homepage.htm.

[89] Koppi, T., L. Bogle, and M. Bogle (2005) Learning Objects, Repositories, Sharing and Reusability. Open Learning, 20(1) pp. 83-91.

federations of learning content repositories.

Designed to be an enabling model to bridge the worlds of learning content management and delivery, and content repositories and digital libraries, CORDRA aims to identify and specify (not develop) appropriate technologies and existing interoperability standards that can be combined into a reference model used to enable a learning content infrastructure.

ADL Registry is an instance of CORDRA. Anyone will be allowed to search the ADL Registry through a portal, but the access to find content may require local access privileges or authentication.

References

<References are now in the footnotes.>