Open Educational Resources and the Transformation of Education

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Introduction

Evolution becomes revolution when the established institutional order changes and new social practices and concepts begin to organise everyday activity and discourse. The Open Educational Resources (OER) movement potentially represents such a revolution. Stanford’s machine learning and artificial intelligence courses enrolled over 260,000 students from more than 190 countries in autumn 2011, spinning-off the two venture capital funded start-ups Coursera and Udacity. The MIT and Harvard University press conference on the edX OER initiative attracted over 35,000 viewers on YouTube after its launch in May 2012. The introductory video for Stanford’s ‘Designing a New Learning Environment’ course, which ran from October 15, 2012 to December 20, 2012 had over 15,000 viewers in its first weeks. In October 2012, on the first day of the Peer 2, Peer University’s massive instructor less open online course (MOOC) on Python programming language, there were 5,814 enrolled students. The numbers are impressive. One teacher, 50,000 students. No teacher, 6,000 learners. Combined with the analytical capabilities of state-of-the-art ICT, this creates possibilities. In the prototype MIT edX course, ‘Circuits & Electronics’, a student obtained 100% on all the assignments. He was a 15-year-old boy from Nepal.

Just like in the other recent hyper-fast developments on the net, there is nothing very new in OER from an ICT point of view. The rapid expansion of social media applications occurs because there are few technical obstacles. As Internet infrastructures have matured to a point where massive numbers of users can be supported at extremely low cost, the speed of technology diffusion is now limited by the users. This dynamic of change is certainly extraordinary, if not revolutionary, and many educational institutions have realised this. Coursera, which provides a platform for universities to roll-out their OER courses, grew from its four founding partner universities to 33 in its first five months in 2012. The OpenCourseWare consortium had almost 200 higher education institutions as its members towards the end of 2012, including the China Open Resources for Education (CORE) consortium, with 35 member universities. The Khan Academy now provides over 3,400 courses and is used by some 3.5 million students each month. The open source learning management platform Moodle has now over 60 million registered users.

Although open educational resources, strictly speaking, do not have to be digital and network accessible, the rapidly declining costs of ICT and the explosive growth of the Internet have been major forces driving the expansion of OER. Internet-based resources have been used in education since the late 1980s, but their use has grown rapidly after Gopher and the World Wide Web provided access to digital documents and multimedia. Since the birth of the Web in 1990, open access to scholarly publications has rapidly expanded (Suber, 2012). Towards the
end of the millennium, there were over 500 peer-reviewed open access journals (Laakso et al., 2011); by October 2012, over 8,000 had been added to the Directory of Open Access Journals (www.doaj.org) hosted by Lund University. There are now over 2900 institutional and cross-institutional open access repositories registered in the Registry of Open Access Repositories (ROAR) (http://roar.eprints.org), hosted by the University of Southampton.

The growth of Open Access has been facilitated by copyright practices that emerged in the free software community in the 1980s. The idea of using copyright to enable access, re-use and further develop digital assets was rapidly taken up in the educational context by David Wiley, who coined the term Open Content in 1998 (Grossman, 1998), and it was more formally developed by the Creative Commons initiative, launched by Lawrence Lessig and his collaborators in 2002 (Plotkin, 2002).

Open source software projects such as the Linux operating system and the Apache http server have also provided a major impetus for OER. Towards the end of the 1990s, the open source movement clearly highlighted the potential of peer-produced resources (Oram, 2001; Raymond, 1999; Weber, 2004), as well as the potential of the collaborative open source development model for knowledge creation and learning (Tuomi, 2002). Many software platforms for learning have been developed as open source projects, including OLAT, started at the University of Zürich in 1999, Claroline (started in 2000 at the Catholic University of Louvain), and Moodle (first released in 2002 by Martin Dougiamas at Curtin University, Australia), which now has over 68,000 active registered sites in 222 countries (http://moodle.org/stats). The open source software development model was also the starting point for Connexions, launched at Rice University in 1999 by Richard Baraniuk. It was designed to create and share peer-produced learning resources as a platform where modular learning objects could be stored, refined, and remixed. It now has more than 17,000 learning objects or modules in its repository, used by over 2 million people per month (http://cnx.org/aboutus).

Open Educational Resources are now viewed as a natural way to implement distance learning, open education and new pedagogical approaches (OECD, 2007; Thomas & Brown, 2011; Okada, Connolly, & Scott, 2012; Ehlers, 2011). As an indication of a widely shared belief that they were going to be a fundamentally important phenomenon for the future of learning and education, the UNESCO World OER Congress in June 2012 released the Paris OER Declaration (UNESCO, 2012) which requests the member states to foster and facilitate the use and development of OER. OER is also one of the priorities proposed by the European Commission in its communication on Rethinking Education (EC, 2012), published in November 2012.

There are many OER initiatives worldwide, and policymakers are actively developing policies in this area (Hylén et al., 2012). The developers and participants of OER initiatives often describe OER as a ‘movement’. As the phenomenon is recent and rapidly evolving, literature on OER remains highly descriptive, prescriptive, and often speculative. To gain better understanding of the developments in this area, Carnegie Mellon and the UK Open University set up the Evidence Hub for Open Education as part of their OLnet project in an attempt to bring researchers and educators together to share knowledge on OER (www.olnet.org). More recently, the UNESCO supported OER community mailing list
was re-launched in November 2012 to try to create a world map of OER activities. In the EU, the POERUP (Policies for OER Uptake) project, funded by the EU Lifelong Learning Programme 2011-2014, is also conducting many case studies to develop recommendations for governments that want to stimulate OER.

In this article, we focus on developing theoretical and conceptual understanding of this potentially important phenomenon. Instead of trying to capture a moving target, the article tries to put OER in a broader context of educational transformation.

Openness is an extremely complex issue that has social, economic, cognitive and technical dimensions. OER also requires that the education institutions reconsider their mandates and roles (McAndrew, 2010; Gourley & Lane, 2009; Butcher, 2011; Schaffert, 2010). Many debates and several recent policy initiatives on open educational resources have focused on no-cost access to teaching and learning materials3 and the economic viability of OER models (de Langen, 2011). In practice, there are many stakeholders, and what is no-cost for someone is not necessarily free for all. Similarly, openness cannot simply be reduced to access. To understand the potential impact of OER, we must provide a more detailed picture of the conditions of openness and the nature of open resources.

This article is organised as follows. The next section defines four key types of OER that will be distinguished in the discussions throughout. Openness and freedom exist in a social context that includes, for example, intellectual property rights, but also many other social institutions. The following section therefore puts OER in a context of social institutions and production and prosumption processes. To provide a critical background to analyse the potential impact of OER in the transition from the industrial age to the knowledge society, the article then revisits four key societal functions of education and compares the ways in which these are implemented in the industrial and knowledge societies. The following section then puts the key technical characteristics of the different types of OER in resonance with alternative models of learning, consolidating these into two dimensions, one focused on the individualistic-distributed axis, and another on a repository-process axis. Using the conceptual outcomes of the previous sections, the article then outlines some examples of how OER could shape the transformation of education and learning. The final section summarises the article.

The Four Types of OER

Open Educational Resources gained visibility in 2002 when UNESCO organised the Forum on the Impact of Open Courseware for Higher Education in Developing Countries. It was partly inspired by the recently published OpenCourseWare Initiative of MIT and initiatives such as MERLOT (Multimedia Educational Resource for Learning and Online Teaching) launched in 1997 in the US.

The UNESCO Forum defined Open Educational Resources as ‘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’ (UNESCO, 2002, p. 24). Later, the restriction to non-commercial purposes was removed, and more recently the definition has been expanded to include non-digital materials (UNESCO, 2012). A frequently used
definition is provided by one of the key funders of OER initiatives around the world, the William and Flora Hewlett Foundation (Atkins, Brown, & Hammond, 2007, p. 4):

OER are teaching, learning, and research resources that reside in the public domain or have been released under an intellectual property license that permits their free use or re-purposing by others. Open educational resources include full courses, course materials, modules, textbooks, streaming videos, tests, software, and any other tools, materials, or techniques used to support access to knowledge.

These definitions are intuitive, but they can be made more accurate by defining what we mean by resources. According to a dictionary definition, a resource is ‘a stock or supply of materials or assets that can be drawn in order to function effectively’ (OECD, 2007, chap. 2).4 Economists distinguish ‘rival’ and ‘non-rival’ and ‘excludable’ and ‘non-excludable’ resources. Resources that are rival and non-excludable are often called ‘common pool resources’. Typical examples include ocean fisheries. It is difficult to restrict access to open seas, but when someone fishes the pool the size of the fish pool available for others diminishes. Unrestricted and unregulated use of common pool resources is usually thought to lead to the infamous ‘tragedy of commons’ (Hardin, 1968), where the resource is eventually overused, depleted, and destroyed.

Resources, however, can also be ‘non-rival’. One of their specific characteristic is that they can be enjoyed without diminishing the enjoyment of others. When resources are non-rival and access to them is not restricted they are ‘public goods’. Knowledge, education, and public parks are often given as examples (Hess & Ostrom, 2003).5 Open educational resources can therefore be described as public goods, and large bodies of economic literature become relevant in explaining why and when policy intervention is justified for such goods.

OER is, however, something more than a public good. When OER is produced in a collaborative fashion where the use and remixing of the content increases the value of the resource, one core assumption of economic theory, the separation between consumption and production, breaks down. The consumption of OER can expand the resource. Open source software and OER have therefore also been described as ‘open fountains of goods’ (Tuomi, 2005). In an open fountain model, the more the pool is used, the bigger it becomes.6 This leads to new models of value creation that cannot easily be analysed using current economic theory or economic policy analysis tools.

Keeping in mind that new theoretical frameworks may also be needed, open educational resources can be defined as accumulated assets that are available in a non-discriminatory way to educators, students and self-learners for learning and education. When they can be enjoyed without reducing the possibilities of others to enjoy them, they are public goods. When the users can re-develop and contribute to the resource, they can also provide ‘fountains of goods’. This definition is somewhat less intuitive and broader than, for example, the current UNESCO definition. It highlights, however, theoretically and practically important distinctions. To make these clear, we separate four types of OER.

The first level of openness is about access and accessibility. A practical criterion for such openness is whether there is a non-discriminatory opportunity to reach,
explore, and study the resource. We call OER that is open in this sense OER I. No-cost access to textbooks is an example. The second level is about the right and capability to enjoy the services generated by the resource. In the Free/Open Source terminology, when a resource is open in this sense, one can ‘use’ it. We call OER that is open in this sense OER II. Whereas OER I enables students to read a book or watch a video, OER II means that they can use the book or video to pass a course or obtain a certificate. The distinction between OER I and OER II is important, as it highlights the social and institutional dimension of openness. It is impossible to see whether a resource is open or not by simply looking at it. OER II emerges as a combination of non-discriminatory access to the resource and a social arrangement that makes it possible to enjoy the services generated by the resource. For example, the MIT OpenCourseWare provides access to recorded lectures and digitised learning materials, but excludes any formal recognition of learning.

OER III emerges when the user has the right and capability to modify and add value to the resource. At this level, the user can remix, contextualise and recombine existing resources, and benefit from the improved resource. OER III makes possible, for example, just-in-time personalised learning.

Finally, OER IV emerges when the improved resource can be redistributed. This is the level where a new accumulative and expansionary dynamic of resource development emerges, as users can become producers who work on the received resource. In OER IV, the underlying growth dynamic becomes exponential and a new collaborative dynamic of learning emerges. OER IV allows, for example, peer-based social learning that focuses on collective construction of knowledge and knowledge artifacts. This model underlies the Scratch software construction environment developed at the MIT Media Lab (Monroy-Hernández & Resnick 2008). Scratch allows young kids to create and programme games and develop and repurpose programmes created by others, at the same time learning from the other users of the platform (Thomas & Brown, 2011).

Many of the most visible OER initiatives have focused on providing free access to difficult to modify content, thus remaining in OER I. OER II has been addressed by initiatives such as the Mozilla’s Open Badge Infrastructure project (http://openbadges.org), which aims at creating an alternative recognition system for skills and educational achievements. The badge approach is also extensively used by the Khan Academy (www.khanacademy.org), whereas Udacity (www.udacity.com) uses peer-based ‘karma points’ and a four-level grading system and has partnered with the electronic testing company Pearson VUE to provide controlled educational certificates. Coursera (https://www.coursera.org), in turn, plans to provide secure testing and assessment services and to collaborate with its partner institutions to certify learning achievements. Also edX (https://www.edx.org) is now planning to move towards OER II, as it plans to provide certificates of course completion. Coursera and edX, however, move with one foot solidly on each side of the fence, providing open access to learning with restricted, though perhaps low-cost, access to the benefits of education.

Whereas, from an economic point of view, OER I, II and III can be seen as public goods, they also show that OER and its impact can be understood only in a broader social and institutional context. The impact depends on the conditions in which the user can enjoy the services generated by the resource (Willems &
These include technical capabilities such as network access and software that can effectively re-use and represent available content, but also base-level competences and social, economic, cultural and political conditions.

It is therefore necessary to locate specific open educational resources in a broader context where these resources are created and generate services. In the next section we briefly outline this broader context. An important element is the prevailing intellectual property regime. Intellectual property rules, however, represent only one of the many social institutions that regulate how OER can generate benefits for its users, producers, and society.

**OER in a User-producer Context**

When OER consists of textual content, copyright rules to a large extent define the level of resource openness. OER I and II, for example, can be implemented using the Creative Commons ‘no derivatives’ licences, whereas OER IV can be enforced by ‘share alike’ licensing (http://creativecommons.org). In general, copyright licences only partially define the openness of the focal resource. Resource openness can also be constrained by trademarks, database rights, patents, and proprietary file formats. Content use may be facilitated by fair-use rules and constrained by cultural norms as well as liability and national security laws. Many OER initiatives have so far focused on content that can be effectively regulated using copyrights, and the complexities of openness have remained relatively invisible. In particular, when OER is used to redistribute existing course content, which normally is adapted to local norms and laws, openness often seems a question of copyrights.

In general, the focal OER is not a monolithic object and may consist of components that have different degrees of openness. Conceptually, OER can perhaps best be viewed as boundary infrastructures that enable knowledge-based collaboration across diverse groups of actors (Star, 2010; Bowker & Star, 1999). This heterogeneity has implications both for the creation and use of the resource. For example, the possibilities to remix resources and create effective learning paths depend on the granularity, modularity, configurability, and scale of the focal OER. When OER moves beyond simple resource library models, for example, when OER platforms support dynamic configuration and personalised assessment, the technical dimension of openness becomes important, including interoperability, standards and interfaces.

From a pedagogical point of view, learning often requires guidance and scaffolding that help the learner to proceed effectively and avoid sidetracks and cul-de-sacs. Such guidance can alternatively be viewed as a resource or as a constraint (Giddens, 1984). A distinction between ‘open’ and ‘closed’ educational practices is therefore complex both in theory and in practice.

In some cases, it may be useful to explicitly restrict the openness of some components, not only for the users, but also for the producers. For example, the rapid growth of source code of the Linux open source operating system has been facilitated by strong social control of some of its key elements. Although in open source projects the code is visible to all developers, not everyone is allowed to modify it. In the history of Linux, tight control of central elements has enabled rapid expansion of more peripheral elements, leading to very high rates of expansion in the overall functionality of the system (Tuomi, 2001; 2002).
To simplify this complexity, in Figure 1 we depict three important domains that form the context of OER initiatives. First, the production of OER requires motivation, capability, and a resource base that is used in the production process. Second, the resource base that forms the context for production consists of tools, accumulated epistemic objects, as well as established communities with division of labour and rules that make collective effort possible. Third, the use of the produced OER generates knowledge and capabilities and can also produce further epistemic objects and tools. As consumption is in itself productive and the ‘consumers’ of learning cannot readily be conceptualised as ‘sinks of knowledge’, we use the term ‘prosumption’ here. As the different models of learning require different degrees of heterogeneity, configurability and scale of the focal resource, we also single these out in Figure 1. As it highlights, openness of the focal resource makes sense only in a broader context that provides explicit and tacit rules that simultaneously constrain activity and make it possible. These rules encode substantial bodies of social knowledge and structure that have gradually evolved to address the needs of social life. To put it in very simple terms, these rules and structures define why learning and education make sense in a specific historical context. In the following section, we therefore briefly outline this historical context in an attempt to clarify why and whether OER could make sense in the educational systems of the future.

**OER and Learning in the Knowledge Society**

Each historical era creates an education system that addresses its needs. The diffusion and impact of OER partly depend on whether it makes the current educational system more productive and effective. OER, however, can also be a transformative force. It can help current educational institutions to adapt to emerging social requirements and provide a breeding ground for qualitatively new
systems of learning that emerge outside current institutional frameworks. The impact and future of OER therefore depend partly on how its evolutionary dynamic and its propensities and possibilities align with the requirements of current educational systems, and partly on how it allows these systems to respond to the requirements of the post-industrial knowledge society.

In the pre-industrial European society, the family and the immediate community were the focal points in education and children were able to perceive and participate in almost all productive activities. As Dewey noted:

The supply of flour, of lumber, of foods, of building materials, of household furniture, even of metal ware, of nails, hinges, hammers, etc., was in the immediate neighborhood, in shops which were constantly open to inspection and often centers of neighborhood congregation. The entire industrial process stood revealed, from the production on the farm of raw materials, till the finished article was actually put to use. (Dewey, 1915, p. 23)

In contrast to this transparent system of production, the industrial system created a complex division of labour and specialisation where the household lost its capability to provide vocational education and where specialised locations of learning had to be set up. The rapidly accelerating urbanisation and migration, driven by the increasing role of factories as centres of work and earning, also generated unprecedented social diversity. In this process, the home, the workplace, community life, and the church lost many of their earlier functions in the educational system, and the school became a central institution in education.

The industrial mode of production therefore did not only lead to a problem of transferring productive skills; it also generated important new requirements for education. First, the effective combination of human workers with machinery requires clocks, punctuality and tight coordination. Second, the slicing of productive activities into specialised tasks requires hierarchical control, coordination and obedience. Third, factory workers must accept the fact that the motives and meaning of productive tasks are increasingly unknown. Fourth — especially after the introduction of scientific management methods in industry —, workers had to be able to read and write documents that defined work processes and standards.11

The gradually increasing wealth, health, and leisure time, combined with rapidly increasing rates of literacy, also enabled people to search for new sources of meaning. As Inglis (1918, p. 373) noted in his extensive study on the aims and functions of education: ‘Factory labor has tended to reduce the economic activity of the worker to a level of deadening monotony where either development or enjoyment is reduced to lowest terms’. Formal education was thus also needed to compensate this decline in opportunities for personal development, as well as to provide the foundation for effective coordination, management, and collaboration of increasingly complex and diversified societies. With some simplification, we can thus say that the modern educational system responds to four major societal needs.

First, from a systemic point of view, education simplifies social complexity and increases its predictability (Luhmann, 1995). It has an important role in reproducing and creating social groups and social stratification. It generates social categories that collate large numbers of individuals in groups that can be represented by statistical numbers with prototypical characteristics, making planning and large-scale administration and thus the modern state possible (Webster, 1995, chap. 4; Giddens, 1985).
Second, as noted by Dewey and others, the industrial system requires specialised education of productive skills and also more general-purpose competences such as literacy and numeracy that make efficient production possible. Literacy and numeracy, in particular, have been the key competences required by efficient coordination and control of productive processes in the industrial age. In advanced economies, the expansion of production and consumption has also been supported by the fact that schools have allowed parents to go to work outside the home.

Third, education also generates attitudes and knowledge that, beyond their effect of production, underlie political and cultural systems and provide the foundation for society. This is the ‘cultural transfer’ and ‘enculturation’ function of education. Education is required to make full social participation possible.

Fourth, modern education also aims at personal development. The importance of personal development and ‘the complete fulfillment of man, in all the richness of his personality’ (as stated in the Learning To Be report by UNESCO (Faure et al., 1972)) have been emphasised since the romantic image of individuals became popular in the early 19th century (Taylor, 1989).

The four functions of social simplification, productivity, cultural transfer, and personal development are rather generic and could be compared with the more learner-focused four pillars of learning defined by UNESCO (1996, chap. 2). The way in which these are implemented, however, varies in different social, historical, cultural and techno-economic contexts. Education reduces social complexity; it increases the efficiency of productive processes; generates socially shared systems of meaning that enable collective action and social development; and facilitates individual development and realisation of human potential. The ongoing transformation from the industrial to the knowledge society profoundly changes the conditions for implementing these social functions, and OER potentially plays an important role here. It is in this context that the potential impact of OER is most clearly visible.

Table I compares the different ways to implement the four societal functions of education in the industrial and knowledge societies. In this article, we do not detail these differences. Instead, they are used to highlight the societal level of analysis that puts OER in an historical context. Here, we define social functions and ‘demand’ at a level that is independent of their technical implementation, thus avoiding the old dichotomy of technology push vs. demand pull. The question about ‘social demand’

<table>
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<tr>
<th>Social function</th>
<th>Industrial Society</th>
<th>Knowledge Society</th>
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<tr>
<td>Stratification / simplification</td>
<td>Hierarchical</td>
<td>Networked / heterarchical / informational</td>
</tr>
<tr>
<td>Productivity</td>
<td>Specialised and mechanised work</td>
<td>Continuous learning, meaning</td>
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<td>processing, and knowledge creation</td>
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<td>Enculturation</td>
<td>Unified national cultures</td>
<td>Cultural diversity, transient</td>
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<td>communities and networks</td>
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<td>Personal development</td>
<td>Trans-generational progress, realisation of latent</td>
<td>Realisation of human capabilities, increasing capability</td>
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<td>individual potential through vocation and social role</td>
<td>to realise value and make choices</td>
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for OER then simplifies to a question as to whether OER provides some clear benefits in implementing the technology-independent social functions of education. To address this question, we must understand whether the wide use of OER could make learning more productive and the education institutions better adapted to the needs of the knowledge society.

**Learning with OER**

Given the different types of OER and the context in which they are produced and prosamed, we may now try and clarify the impact of OER on learning and education. As Kools and Istance (in this issue pp. 43–57) emphasise, the availability of a new technology does not lead to any deterministic outcomes or impact, and emerging technical possibilities can be used in many ways. It is possible to implement all existing pedagogic models using OER. At the same time, OER has specific propensities and affordances that better match some models of learning than others. To consolidate the vast area of often contested and conflicting views of what learning is and how it happens, we focus on two analytical dimensions: the unit of analysis and the degree of explicit learning dynamics.

In the dimension that distinguishes different units of analysis, we separate individualistic and distributed models. In degree of dynamics, we distinguish between models that view learning as transfer of knowledge to a repository and models that are based on more elaborate process models of learning. At the individualistic end, we locate those behaviouristic, cognitivist-representational, associationistic, and neural learning models where the unit of analysis is the individual learner. At the distributed end, we include socially and socio-materially distributed models. Using these two analytical dimensions, we map the previously introduced four types of OER in Figure 2.

![Figure 2. Learning models and the four types of OER](image)

In this picture, the traditional knowledge transfer model of instruction would be located at the individualistic and repository end. This is the ‘storehouse of ideas’ model where the human memory provides a repository ‘where the mind can lay up those ideas which, at another time, it might have use of’ (Locke, 1979, p. 150). The distributed models of learning would, in turn, include a large interrelated
cluster of cultural-historical, activity-theoretic, socio-cultural, situated, ecological, distributed, and extended cognition models. The far end of the distributed side would also include community-oriented constructionism, design learning, and the trialogical model (Kafai & Resnick, 1996; Paavola & Hakkarainen, 2009), as well as the knowledge building model of Scardamalia and Bereiter (2006; Bereiter, 2002), where the unit of learning moves, at least partially, to the world of collectively shared knowledge objects. Distributed models of learning, by their nature, tend to incorporate process aspects. These, however, become pronounced in explicitly cyclical models (Kolb, 1984; Nonaka, 1994; Engeström et al., 1996), as well as in reflective (Schön, 1987) and action learning (Boshyk & Dilworth, 2010), but also in Schank’s (2011) recent reinterpretation of the cognitivist model.

There are many learning models, and often they are complementary, overlapping, and contradictory. The concept of ‘resource’ already implicitly assumes productive use, and OER therefore easily aligns with constructivist and constructionalist models. When OER provides digitised network accessible resources it also aligns well with distributed models.

An alternative view of these analytical dimensions is provided by mapping open licences to the picture. Figure 3 shows that there is a close correspondence between licensing conditions and specific learning models. Whereas, for example, the Creative Commons ‘attribution’ licence (CC BY) can support the entire spectrum of learning models, the ‘no derivatives’ licence (CC ND) effectively inhibits distributed and process-oriented learning models. The Creative Commons ‘share-alike’ licence (CC SA), in turn, only becomes salient when the underlying learning model is socially distributed and the learning process unfolds in time. By enforcing re-usability and further developments, the CC SA licence thus aligns well with collaborative and constructionalist models of learning.

Figure 3. Creative Commons licenses and their respective learning models

The above analysis provides a highly simplified picture of the key affordances of the different types of OER and their relations with different models of learning. It is possible to combine process-based and repository models, for example, by adopting a learning model that incorporates learning processes that occur in different time-scales. The Vygotskian model, for example, is based on such a layered model of development (Luria & Vygotsky, 1992). It is, however, clear that different types
of OER resonate with different types of learning models. We may therefore ask whether distributed and process-oriented models of learning would be more effective than individualistic repository-oriented models and whether OER could release hidden learning potential and improve learning productivity. If learning is difficult today because of material, social and economic constraints, would OER make a difference? If education implements its societal functions in ways that try to optimally address the concrete requirements of the industrial age, would OER facilitate the renewal of existing educational institutions?

**OER and the Transformation of Education**

Using the four social functions of education listed in Table I and the outline of the propensities and affordances of OER presented in the previous section, we can now ask whether OER can be used to move education from the industrial era to the knowledge society.

It is clear that the wide use of networked information and communication technologies, as such, has already created means for social simplification and stratification. Internet search engines and social filtering and recommendation systems are able to dynamically cluster and profile vast numbers of users at scales unimaginable just two decades ago. Education, at least to some extent, is being replaced by ‘big data’ and statistical methods. It therefore plays a rapidly decreasing role in social simplification and stratification. In the networked, heterarchical and dynamic knowledge society, the simplification of social complexity cannot easily rely on slowly changing established hierarchies and fixed social roles.

The cultural transfer function, in turn, is increasingly implemented in culturally diverse contexts where identities and communities are dynamic and transient. Education thus moves from trans-generational ‘vertical’ socialisation to peer-based ‘horizontal’ social learning. This is clearly compatible with the basic characteristics of OER IV. On the other hand, OER also enables growing contextualisation and localisation of the production of knowledge and learning, allowing different communities to develop local systems of enculturation. OER can therefore also facilitate the emergence of geographically, ethnically, and culturally specialised education and, for example, the expansion of value-centric education and anti-schooling movements where identities are constructed with strong community-specific values.

Through its capacity to provide wide access to customisable and configurable learning resources, OER III will clearly have a major impact on possibilities for personal development. As individual identities are essentially social constructs, OER IV enables learning that is strongly linked to identity formation and the expansion of personal expression. OER thus facilitates just-in-time personalised and self-directed learning and provides new possibilities for identity construction and expression in a wide variety of globally distributed communities. Because of its capability to make learning socially visible and connect peripheral stakeholders to learning processes it also facilitates learning models that connect learning to social change. OER can therefore support the expansion of action learning and critical pedagogies, and, for example, reduce the ‘isolation’ and ‘encapsulation’ of school learning (Engeström, 1996).

The potential impact of OER on the productive dimension is more complicated. In the industrial age, specialised skills were critical for productivity and were typically complementary to specific tools used in production. In a given material and technical environment, such as the factory floor, it is possible to
define relatively static catalogues of skills and provide training that is related to
them. In this sense, the concept of skill is an artifact of the industrial model of
production.

In knowledge-intensive production, many of the traditionally well-defined skills
become outdated. The context of work is not a static production line on a factory
floor; instead, it is a dynamic and continuously changing landscape of learning and
knowing. Much of the traditional educational content that focuses on productive
skills thus becomes irrelevant as we move towards the knowledge society. Wide
access to outdated content does not necessarily lead to more productive societies.
The impact of OER on society’s production potential, thus, depends on how well
the pedagogic models used in OER support the development of those capabilities
that are productive in the knowledge society. At present, this is still very much an
open research question. Abstract and generic ‘21st century skills’, such as innova-
tion and problem-solving capabilities, communication skills, and ‘learning skills’
may require new educational practices and cultures. A straightforward promotion
of OER may diffuse outdated pedagogic ideas and content, thus reducing instead
of increasing the productive potential.

A major promise of OER is that the creation and refinement of both learning
content and the underlying pedagogical approaches can benefit from the distrib-
uted co-creation model enabled by open licences. In principle, a rich developer
base facilitates the creation of resources. In practice, the benefits may depend on
the type of content and resource developed. This is perhaps best illustrated in a
Hayekian model of knowledge creation. For Hayek (1945), a knowledge-based
economy is characterised by the fact that no single individual is able to know as
much as all social actors know together. According to Hayek, important stocks
of socially relevant knowledge are tacit. In addition to these tacit bodies of
knowledge, people rely on their personal, local, contextual and idiosyncratic
knowledge when they make consumption and production decisions. Hayek’s
argument was that because of this distributed and tacit nature of socially
and economically relevant knowledge, centrally planned policies and explicit
organising almost always performed worse than a free market of ideas and
action.15

Open source and open content developer communities have characteristics that
resemble Hayek’s free markets of knowing. In principle, when each developer is
able to contribute their unique knowledge and competences to a collaborative
project, the outcome can exceed the possibilities of any single actor or any centrally
planned effort. We may call this the ‘Hayekian benefit’ of OER which has been
visible in open source software projects. Software development, however, is special
because the developed code also provides unambiguous methods for verifying
efficiency and knowledge claims (Tuomi, 2002). The code can be executed and its
performance be objectively measured. When such objective criteria do not exist, as
is the case, for example, when many persons develop content in parallel for
WikiPedia, joint effort does not necessarily converge towards a stable outcome. In
a world of many conflicting truths, the benefits of distributed collaboration can be
limited.

In some cases, the ‘objectiveness’ of knowledge can be verified empirically. In
others, the benefits of idiosyncratic personal knowledge may be limited because
knowledge is inherently social. For example, natural sciences and mathematics
rely on theoretical conceptual systems that embody trans-generational and
interpersonal knowledge. As Vygotsky (1986) pointed out, there are essentially two types of concepts. Some are ‘spontaneous concepts’ that a child learns in interaction with the material and social environment. According to Vygotsky, advanced forms of thought emerge when these spontaneous concepts are replaced by ‘theoretical’ concepts. These systems of ‘theoretical’ concepts are socially and culturally shared and generated and are acquired gradually in social interaction as the human mind develops its advanced mental capabilities.

For these types of knowledge systems, the Hayekian benefits can be reduced to a simple mechanistic division of labour. Personal knowledge and diversified views about what is the result of multiplying two numbers may not exist. When coordination costs are low and joint effort is easy, crowds may work effectively for a joint objective. When local interpretation and personal knowledge have limited relevance, and knowledge is inherently social and explicit, central planning and organising may be more effective. In such a situation, the OER model, as a distributed peer-production model, may have little benefit and the costs of collaboration may easily prevail.

From a learner-centric point of view, OER facilitates distributed learning processes where resources can be dynamically adapted according to specific learner requirements and where learners can efficiently borrow cognitive capabilities from their social and technical environment. Learning can potentially be very effective and productive in such an environment. Personalised and networked learning environments may thus look attractive and promise great improvements in learning productivity. Such personalised models, however, require extensive systems of learning diagnostics and analytics that may be difficult to implement in open environments. In practice, they require detailed information about the current knowledge and capabilities of individuals. This creates radically new domains of social transparency. Many current OER initiatives, for example, aim at providing detailed data on the progress of a student to the teachers and parents. A limited but interesting example of such a new régime of social visibility is also included in the list of possible monetisation approaches proposed by Coursera to its stakeholders and venture capitalists (Young, 2012). In this business scenario, Coursera would make money by opening student records to potential future employers so that the students can reveal their learning achievements and the employer can select the best performing students.

At a more societal level, and perhaps more fundamentally, it is at present unclear to what extent the traditional productive function of education remains relevant in the knowledge society. Learning will clearly have a major impact on how and what society and its members produce. As was pointed out above, the current educational system responds to the historical need to generate generic competences and specialised skills that are needed in the industrial system of production. The ways in which these are articulated today are to a large extent based on a model of production where humans and machines are coupled together in an industrial machine. The essence of the industrial system is in its capability to mix human and mechanical actors to produce higher volumes of output. As has been pointed out by Zyman (2006), the emerging ICT-enabled networked production models are not necessarily compatible with this industrial model of production. In the current global and networked world, where networks of production are dynamically configured on demand with the click of a mouse and a tap of a finger, there is no time or space for human intervention in the actual production process. This means that
all those tasks that are rule-based or can be routinised need to be implemented using algorithms if they are to be connected to the global network of production. This is the ‘algorithmic revolution’ highlighted by Zysman. In practice, this could mean that almost all those specialised tasks for which the industrial age educational system tried to produce skills will become obsolete as the knowledge society transformation proceeds. There may therefore be little benefit from the rapid expansion of access provided by OER if it supports vocational learning, but also learning in areas commonly associated with white-collar knowledge work.

**Conclusion**

The very rapid expansion of the number of OER initiatives and the millions of learners they attract can easily be interpreted as an indicator of a forthcoming revolution in education and learning. This article has developed a conceptual background that can help to study this potential revolution in its broader social, economic, and historical context. Technology never determines social outcomes, and the ways in which OER will be used largely depend on its capacity to make learning effective and address existing and emerging social needs for education.

This article started by defining four different types of OER. Methodologically robust studies on OER require different ways to frame these different types of OER. We outlined one way to put OER in the context of production and prosumption that highlighted the importance of the social and institutional foundations that make OER meaningful. To understand this social context, we then in a very compressed way described the historical origins of current educational systems as a response to social needs that emerged in the industrial revolution, highlighting the different ways in which solutions for these social needs are implemented in the industrial age and in the knowledge society. The underlying argument was that the current education institutions are solutions to historical needs, articulated under the constraints of the past. When the constraints, needs, and the underlying conceptual frameworks change, educational institutions respond to these changes. Against this background, we tried to see whether and how the different types of OER could be part of the transformation of education and learning.

The approach was multidisciplinary. It may appear theoretical from the point of view of an educator or a policymaker who thinks that the issue is about free access to textbooks, wide access to high-quality teaching, and the wonders of social media. We supported the argument using literature that ranged from economics to innovation and technology studies, sociology, learning theories and the history of education. It is, of course, only possible to scratch the surface here. The point, however, is that education is a deeply social and historical issue and that, as Olson and Bruner (1996) pointed out, the institution of education is inextricably linked with our ideas about what knowledge is and how learning occurs. To understand and study the impact of OER in education and learning, and to develop useful policies we must put OER in this broader theoretical context. OER is not just textbooks in cyberspace. If it is anything, it is part of a highly complex and continuously evolving system that plays an important role in making effective human collaboration and individual creativity possible.

Beyond descriptive reviews of this rapidly moving phenomenon, a study on OER is therefore inherently a study on social and educational transformation. OER reorganises the boundaries of social transparency and enables new forms of
collaboration and production. In so doing, it provides a rich field of research on both the current and the emerging forms of education and learning. The OER movement is itself driven by rapidly changing information and communication technologies, which are profoundly transforming social interactions, systems of production, and the possibilities for individual development and expression. The emerging knowledge society will have new requirements for education and new models for learning. In this transformation, OER will most probably be a central element.

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NOTES

1. The data in this paragraph come from the respective websites.
3. For example, in October 2012, California decided to create a website that would give students free digital access to 50 core textbooks (www.20mm.org). In April 2012, as part of its Digital School programme, Poland adopted regulations that would create free textbooks for grades 4-6 in primary schools (http://nowoczesnapolska.org.pl/2012/04/03/free-textbooks-are-part-of-digital-school-programme). In July 2012, the Finch report recommended that the UK adopt a clear policy direction towards open access. The Guardian called this ‘the most radical shakeup of academic publishing since the invention of the Internet’ (Sample, 2012).
4. The OECD definition is based on an unpublished background report by Tuomi (2006). The present section draws on this report.
5. Whether education really provides an example of a public good is, however, a rather complicated issue. Education can also be viewed as a defensive cost that people must spend to avoid falling behind others in job-market queues (Thurow, 1975). For this reason, expenditure on education is partially counted as investment and partially as cost in some indicators of sustainable economic growth (Daly & Cobb, 1989).
6. OER can also be described as ‘private production of public goods’ (O’Mahony, 2003; von Hippel & von Krogh, 2003), and ‘commons-based peer production’ (Benkler, 2006). Historically, the ‘increasing returns’ to scale of production is a complex and contested issue (Buchanan & Yoon, 1994).
7. ‘Non-discriminatory access’ has social, cultural, economic, technical, and individual dimensions that can best be understood in the capability-based approach developed by Sen and Nussbaum (Sen, 2000; Nussbaum, 1995).
8. In some countries, copyright law may also force partial Openness II, for example, through fair use rules.
9. This was one of the insights of Vygotsky’s zone of proximal development, which also provided the starting point for the community of practice models of learning (Lave & Wenger, 1991; Brown & Duguid, 1991).
10. Open and closed models of learning have been distinguished in the recently finalised EU-funded Open Educational Quality (OPAL) project (Ehlers, 2011). Ehlers describes open educational practices as a movement from closed to open models of learning, emphasising that OER must be understood in a context of learning that extends beyond the focal resource. The importance of open practices has also been emphasised by Yin and Fan (2011).

11. This section draws on Tuomi & Miller (2011).

12. The four pillars of UNESCO distinguish ‘learning to know,’ ‘learning to do’, ‘learning to live together,’ and ‘learning to be’.

13. More modern versions of repository oriented models would include the script, schema, and cognitive frame models inspired by Bartlett, Piaget and AI, but also many recent models influenced by cognitive neurosciences.

14. An example of a highly distributed model would also be the connectivist model proposed by Stephen Downes and George Siemens. In this model, learning consists of the formation of connections between nodes of information, and ‘learning is the network’ (Kop & Hill, 2008). Assuming the existence of mechanisms that drive changes in the network, connectivism could perhaps be understood as a self-organising network model of collective cognition, extended to an abstract world of information. Whether this would lead to a 19th century associationistic view of learning or new insights remains unclear until the basic concepts of this model are further elaborated.

15. Hayek, who viewed the economy as a collective learning process, developed this argument in many writings, nowadays frequently and rather liberally quoted by anti-government and libertarian movements. Hayek’s views on the nature of knowledge were influenced by his discussions with Michael Polanyi, who is today best known for his concept of tacit knowledge (Mirowski, 1998).

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