December 15, 2013

Ruminations on Research on Open Educational Resources[1]
Marshall S. Smith[2]
Carnegie Foundation for the Advancement of Teaching

ABSTRACT

Open Educational Resources (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 and re-purposing by others."[i] MIT's OpenCourseWare and the Khan Academy materials are well-known examples. OER have different properties from proprietary materials because they are legally free, and, depending on the license selected by the creator, may be copied, reused, revised, remixed, and redistributed. While we understand their properties, we have only a beginning understanding of how OER are used and whether the properties add value for users when compared to similar proprietary materials. This paper explores nine areas of research on OER from policy to development to its relative effectiveness and whether it stimulates innovation. Although existing research is considered, greater attention is given to the possibilities for new research in these areas.

Introduction

A recent report from the Council of Economic Advisors to the President of the United States found that many educational technologies have received no independent evaluation. Moreover, the report noted that the effectiveness of the technologies depends on how well they are used and in which contexts.[ii] The Council summarizes its findings with "there are considerable limitations in our

---

existing knowledge about how to design and deploy these tools."[iii] The report argues for more and better research.

There are reasons for this state of affairs. Technology changes very quickly. Consider, for example, the rapid evolution from radio to video to computers and the use of the Web in the past 50 years. It takes a lot of time and money to carry out a serious experiment or a longitudinal study, and there are many different kinds of educational interventions. There also is a lack of agreement about appropriate metrics and considerable variability in the purpose, quality and scale of the technology applications.[iv]

At the same time, many widely-used educational technology materials are proprietary, and for-profit organizations rarely release evidence generated by evaluations of their products. The upshot of all this has been numerous independent single case studies, a few dozen randomized design studies, and many quasi-experiments, producing a wide range of generally weak claims. Apart from basic knowledge from the field of instructional design, few strong and broadly applicable conclusions have been reached about how to improve the processes of production and implementation of educational technology, or its added value to users (teachers, students, other learners) from the perspective of either cost or educational effectiveness.

Since OER are part of the overall teaching, learning, and technology domain, they would benefit from new studies that are carried out on any form of educational technology product. After all, if a proprietary product is shown to add value to student learning beyond the expected level of student achievement in conventional classrooms, there seems every reason to believe that a similar OER product would be at least as effective.

If this is the case, do we need to plan for research specifically on OER? Why not just improve the quality and extent of research and evaluation on education applications in general?

That would be a mistake. *I explore the hypothesis that the characteristics that define OER potentially "add value" that exceed and/or are different in nature from the effects achieved by a similar piece of non-OER technology or content.* This paper examines these characteristics, looks at evidence that supports the argument or works against it, and suggests avenues of research to determine the power and extent of the effects these characteristics might produce. My concurrent goal is to help develop the outlines of a coherent and usable knowledge base for the OER field.

Deepening our understanding of how OER add value will provide important information as we seek ways to improve the development, use, and effectiveness of OER. But before we explore the question of added value, we should recognize another major and pressing reason for investing in studies of OER. These forms of educational resources are a relatively new and potentially disruptive entry into the world of education. The barriers established by standard practice are often hard to overcome. Reputable knowledge about whether or not OER produce positive gains on measures of access, efficiency, and effectiveness is important to teachers and to policy makers.

Without credible evidence, policies about OER are justifiably vulnerable not only to the general reluctance to change past practice, but also to a range of arguments including, "If it is free it cannot be worth much," and "How do we know your product is effective if it doesn't come from a proven publisher?" Ironically, in the long run, one by-product of high-quality OER research might be to turn this argument on its head and force publishers to improve their products and make their evaluations open to public scrutiny.

This paper builds on and complements the work done at the OLnet,[v] a joint project of the Open University in the United Kingdom (OU-UK) and Carnegie Mellon University. Other important organizations that participate in OLnet include the International Development Research Centre in Canada (IDRC), UNESCO, OECD, Brigham Young University, the Commonwealth of Learning (COL), the Open Universiteit of the Netherlands, Creative Commons (CC), and the University of Michigan.[vi] Much of the OLnet work has been informed by data gathered from a

number of important OER interventions and activities. Other data come from case studies describing, evaluating, and suggesting ways to improve the processes of development and use of OER, as well as to assess their effectiveness on teaching and learning.[vii] The work at OLnet is being taken forward by the OER Research Hub, also based at OU-UK, which will carry out "research on the impact of OER on teaching and learning practices."[viii]

IDRC is currently developing a research network that supports work on OER by local researchers in developing countries.[3] Meanwhile, at Brigham Young, David Wiley and others have carried out important research on the cost effectiveness of OER. The University of Michigan has engaged in a university-wide effort to use and carry out research on OER, which it describes on the Open.UMich.edu site.[ix] The UNESCO Chair in OER at the Open Universiteit of the Netherlands has initiated and currently is coordinating the Global OER Graduate Network (GO-GN), which connects PhD students and their supervision teams in a wide variety of OER related studies worldwide.[x]

What areas should research about OER address?[xi]

This paper explores the need for research in areas, or "buckets." I describe the areas, point to examples of research in each one, and indicate challenges where research could be useful. In essence, the discussion of each bucket is a short essay. In the course of each discussion, I make some initial recommendations about what might be usefully funded by a foundation or government. I hope others will read this, correct it when necessary, and add to the lists of studies.

The studies fit into nine research buckets: A) Policy Research—studies of how and why OER might be better embedded in local, state and national policy and practice; B) Access and Use—studies of how OER add value by increasing access and use, including going to scale; C) Effectiveness—studies of how OER improve outputs and outcomes (learning, efficiency); D) Innovation—investigations into new ideas and possible creative disruption arising from the use of OER; E) Beyond Formal Education—research on the use of OER in other sectors, including public

---

[3] In full disclosure my son, Matthew L. Smith, is involved with this project in his work at IDRC.

health and agriculture; F) Sustainability—research on the viability of OER products over the long term; G) Development and Improvement—studies to understand and improve the processes of creating, altering and using OER; H) Implementation—studies of the processes of introducing and using OER around the world in classrooms, schools, districts, states and countries; and I) Infrastructure—research on the underlying framework and health of OER and the institutional ICT infrastructure.

Many studies will fit into two or more buckets, as researchers explore the main effects and interactions among the various research questions. Because the text in each bucket is meant to stand alone, some redundancy is inevitable.

A note to the reader: the nine buckets do not need to be read in order. For readers unfamiliar with OER I suggest reading Bucket B first. Then you might select a bucket based on your interests. My favorite is Bucket D, which explores ways that OER might stimulate innovation.

Bucket A: Policy Research.

This bucket contains two sets of issues. The first suggests research to examine the positive and negative factors in the political environment that influence whether or not governments at various levels will create progressive OER policy. This would require multiple case studies in different settings that ask similar questions about how, under what circumstances, and by whom, effective policies that support OER could be put into place. The analysis of results from such studies would require stratification by different forms of governmental systems, different levels of government, and different levels of the post-secondary and primary and secondary education systems.

A second area for policy research would require us to examine the characteristics and effectiveness of the variety of educational policies that constrain or enable the use of OER that currently exist in different countries and local jurisdictions. What are the characteristics of education policies that support the development, adoption, and effective use of OER? What form do they take? How broad or narrow should

such policies be? Are there important political and substantive tradeoffs required to create the policies?

A number of groups are already studying these issues. For example, a new project, Policies for OER Uptake (POERUP), is "carrying out research to understand how governments can stimulate the uptake of OER by policy means," and the Open Policy Network, organized and led by Creative Commons, collects data on existing policies and supports the development of new open policies in nations throughout the world.[xii] The database is potentially a great resource for research. But more needs to be done.

Bucket B: Access and Use—Research on Adding Value by Increasing Access and Going to Scale.

This category includes one set of the typical questions asked about OER. Because we make the assumption that an OER can do whatever a similar proprietary product can do—other things being equal—our specific interest is in figuring out whether an OER adds value beyond the effects of similar commercial products. Do the OER characteristics that distinguish them from commercial products add value? What creates the "added value?" How do we document this with valid evidence?

The three characteristics of OER that distinguish them from commercial products are that OER are 1) free for direct access to view; 2) free to download, copy, share, use, and reuse in intact form; and 3) free to revise, remix, reuse, and redistribute.[xiii] Not all OER have all of these legal freedoms but a few go a step further to allow 4) commercial use of their materials.

A first way to start documenting the effects of OER is to compare the probable amount of *access/opportunity* of an OER with a similar commercial product. Who are the users of the OER? How many people are given the opportunity to learn from it at any given time? Is that number different from how many are given an opportunity by a similar commercial product? Can an OER product go to scale more easily than a proprietary product? What are the marketing benefits that come

from a resource being proprietary and how do they compare to the benefits accruing from the OER being open?

A main characteristic of an OER—that it is free to view—would seem to ensure it provides greater access to a greater number of people than a similar commercial product that is not free. If YouTube or a MOOC[4] charged even a pittance for viewing a video they surely would have fewer users.

The freedom for anyone to view these materials all over the world gives them an extraordinary spread of access when compared to many proprietary products. For example, some of the MOOCs have drawn over 100,000 students with perhaps 15 to 25 percent completing the course. If the average class size in the university were 100 students and all completed the course, it would take between 150 and 250 years for the instructor of a conventional course to reach the completion number she reached in one year teaching a MOOC.[xiv]   The geographic and demographic spread of access for the MOOC is equally compelling. Of course, many people argue that the experience of learning from a MOOC is very different from the experience of being in a live classroom. This position suggests a need for evidence to tease out the costs and benefits of the various sides of the argument. Let's think about this initial level of openness and usefulness—this access to material that is simply *free* to observe, read, listen to, enjoy and, yes, possibly learn from—as Access level 1.0.

There is some question about whether many of the free-to-use materials should be classified as OER. For many people who work with OER, free is not enough. The fact that almost all MOOCs and many free videos on YouTube do not have a license that allows users to exercise the other rights of an OER excludes these materials from being OER.[5] Thus a distinction is often made between "open" and "free." But, the YouTube videos and MOOCs without a license are free to users, enabling millions of people, who cannot afford or do not want to pay a fee, the

---

[4] Massive Open Online Course, as defined by Wikipedia: http://en.wikipedia.org/wiki/Massive_open_online_course
[5] However, many resources on YouTube are openly licensed, and YouTube provides a way for users to select an open license upon video upload.

opportunity to view and learn from them. Such materials are at least first cousins of OER.

Unless the free materials on the web explicitly grant users the rights, a user is *not* legally free to download, copy, distribute, and share the material. OER materials, on the other hand, are either in the public domain or have a Creative Commons or other license that provides the users with these new rights. The new rights increase flexibility of use, which in turn creates opportunity of greater access. A teacher in Kenya, for instance, is free to distribute OER learning materials to other teachers via smart phones or to make paper copies for her students. The right to download and print materials makes it possible for OER to be used in places where there is no connectivity or electricity. Let's label this added access value of OER—to download, copy, distribute, share, and reuse—as Access level 2.0.

MIT OpenCourseWare (MIT-OCW) offers a license that allows Access level 2.0 as well as other rights, including those permitting users to create derivative works by translating the original materials or otherwise adapting them for their own needs. Translation, for example, opens the doors to all who do not read or understand the original language. Adaptation greatly extends the useful accessibility of MIT-OCW content. Let's call this added value from OER Access level 3.0.

Surveys, case studies, observations, and testimonials all have made a strong case for both the extraordinary reach (the number of users and intensity of use) of OCW and other OER, and for the degree of useful accessibility for OER Access 3.0. *Has any proprietary educational product achieved anything close to the reach of OCW, Wikipedia, PhET[6] and the Khan Academy materials*?

Finally, there is a fourth level of accessibility that the OCW and Khan deliberately restrict in their selections of Creative Commons' licenses—the right for the user to make commercial use of the materials. The PhET simulations, on the other hand, are covered by a license that allows the commercial sector to use them. As a

---

[6] PhET are interactive science and education simulations created the University of Colorado at Boulder. They are available in over 40 languages and have been downloaded and run over 40 million times in 2012 alone.
http://phet.colorado.edu/

consequence, for example, the Pearson Corporation has incorporated PhET simulations into many of its commercial textbooks, increasing the quality of their textbooks while also increasing the simulations' useful accessibility. Let's call this Access level 4.0.

I am certain that these different degrees of accessibility, all other things being equal, dramatically increase the reach and potential usefulness of OER when compared to identical non-OER materials. We have lots of data about the reach of free or open materials from the MOOCs, Wikipedia, the Khan Academy, and universities in the OCW consortium, to name a few. These examples and others support a prima facie argument that free and open educational materials do add considerable value at all four levels of Access.

While existing case studies have taught us a great deal, there remain a huge number of questions to be developed from this "access" framework. Apart from continuing to document the increase in access through surveys, web analytics, and testimonials, we also need to estimate and better understand how often the rights (such as those to download, translate, or otherwise adapt) are exercised and whether—and how—an exercised right adds value to and *beyond access.*

Another useful research topic would be to investigate the local conditions that make it possible to easily and fruitfully exercise these rights. A third topic would explore whether some groups are left out of the opportunity to make use of the OER materials. Very low-income people around the world are likely to have much less access, a condition that must be addressed. Students with disabilities are a very important population to include in the access research. Throughout the world students in this important group have often been shortchanged in their opportunity to have access to critical educational tools and content. The combination of innovation in technology with the freedoms of OER might result in powerful tools for access by this population.

Finally, we need to explore how to accurately estimate the size of effects in our studies of access. We know that many people operate at the edges of the law—by downloading, copying, and distributing materials on the web that are not in the public domain and do not have a license that signifies they are open. Some of this

is done with ignorance of the law. Others may see it as they see crossing a street against the red light when no cars are coming. Still others may deliberately break the rules. Regardless of the reason, the "violations" may reduce the overall impact of the open material to enhance educational access.

As time passes, significant changes in the technology environment will influence the outcomes of studies on these issues. Platforms that allow easy access and tools to support adaptation, such as Connexions and Gooru, and sites including archives, such as OER Commons, are becoming more sophisticated and easy to use. These sites help novice technology users adapt the OER to their purposes. At the same time, some tools and formats—such as flash animation—may inhibit the ease with which materials can be easily adapted to local circumstances. A related issue worth noting is that users in many regions favor smart phones over other forms of technology. This trend may temporarily complicate adaptation of some OER designed for larger screens even while increasing access in areas like Africa. We need to track and better understand major changes in the opportunities for users to adopt and adapt such OER.

A final issue to explore in the area of expanding access is whether OER increase a product's odds of "going to scale." A variety of criteria have been used to define going to scale. These include financial strength, substantial expansion into a variety of environments, and a trusted and widely accepted approach to changing behavior in a field. The unique characteristics of OER (free, open to copy and share, open to adapt, alter, translate, mix, etc.) might be expected to increase the possibility that an OER will go to scale.

For the leadership and faculty at MIT, going to scale in their 2002 vision of OCW meant putting all of their courseware on the Web for free in English, with the objective of reaching interested people all over the world. They had a strategy to provide access to everyone, the financial strength to support that strategy, a powerful vision, and trusted materials. They fulfilled that vision and they are not alone. The Khan Academy videos use the Web to reach over 100 million users, have garnered kudos from important figures in the education field, and intrigued the mass media. PhET, while not as consistently well financed as Khan, still reaches a huge audience, provides "added value" to teachers, and boasts a Nobel

Prize winner in Physics as its founder. The practice of "Open Access," the unrestricted access to research studies on the web, is rapidly spreading across the world. I would argue that all of these OER have gone to scale.

Other OER that have gone to scale include TESSA, the OU-UK collections, Wikipedia and the OCW-C. All are open under a Creative Commons or similar license that allows derivatives. *How many similar proprietary materials have had the same level of success?* What are the common elements in OER that have gone to scale?

However, going to scale is not the only path to success for an OER. High quality, useful OER can be very successful, for example, by serving small niche populations and uses.

Beyond the three criteria mentioned earlier, the success of an OER depends on many factors: how easy the material is to find, use, and adapt to various environments; the user's confidence in the source of the material; evidence about the quality of the material; and whether the material clearly adds value to the work of the potential user. Product design is almost always of great importance.

Perhaps the most useful criterion for a successful OER is that it is able to be easily used and very useful in the environments where it is most needed. The important elements would then be all of those mentioned above but with added emphasis on the ease of adaptation of the OER to local conditions.

The issues of scale and success deserve thoughtful analysis and research. Research could take a good look at those OER that have gone to scale or been otherwise successful, as well as those that might have been expected to but didn't. We need many more studies of these issues. As President Clinton used to say, "It is really hard to get good ideas to travel!"

Finally, we should examine whether the OER movement itself has gone to scale. What criteria should we use? I look at this issue in the last bucket, on Infrastructure.

Bucket C: Effectiveness—Studies of how OER Improves Efficiency and Learning.

"But enough of all this," the politicians and public might say. "We want to know if the OER will save money, improve the quality of education and learning, and be as or more easily accessible than similar proprietary products." An earlier bucket explored the accessibility issues.

Do OER cost less? At first glance, cost-savings would be a likely outcome of using an OER instead of an equivalent proprietary product. But the calculations may not be simple. For example, the costs of creating an OER and of cycles of updating and improvement have to be factored into the overall cost picture, even if the OER is free to the user. We have some data on this issue, including important early studies of a charter high school's open textbooks, as well as studies of savings to community college students in various parts of the U.S. In the charter school study, the savings directly benefited the school, while in the case of the community colleges, the students are the beneficiaries.[xv] In other situations, cost savings might also accrue to states, to districts, or to parents.

These few studies are a start, and provide some evidence reinforcing a logical expectation—that free materials will lower costs. But clearly we need more studies across a wider range of situations, including rich and poor countries and communities, along with a better understanding of whether, when, and how the greatest cost reductions can be achieved without sacrificing quality. As more studies are carried out, we can expect a more complex and nuanced picture to emerge—this would be an important step toward our understanding of how, when, and where it is most useful to use OER.

Do OER improve achievement? We also need a variety of good studies from many different environments to produce valid data on the effectiveness of various OER materials on student outcomes such as achievement and attainment. We have a small amount of data on open online courses, such as those from the Carnegie Mellon Open Learning Initiative.[xvi] Even if the effects of these courses cannot be

attributed to unique characteristics of OER, a result of greater or comparable effectiveness when contrasted with proprietary products would be useful to validate the relative quality of the OER. We also should not ignore data from projects, such as the Charter School in Utah, that use predominately OER materials and whose students are doing well academically. Case studies that show that teachers and students are successful and happy with the quality and usefulness of the open content are important. Perhaps the most researched OER that I know of is PhET, an open suite of science simulations.[xvii] But the PhET project is an outlier.

As the educational landscape changes, the nature and content that we expect of student learning might change as well. A growing literature focuses on the importance of non-cognitive attributes such as perseverance and self-regulation in the development of thoughtful and productive students. Similarly many in the education world are talking about 21st century skills, including problem solving, creativity, collaboration, and transfer (of a concept from one environment to another). Some OER materials exist to help students learn some of these skills. For example, in the area of problem solving in science, PhET is an excellent option; and the Concord Consortium's Molecular Workbench is an open virtual laboratory where experiments can be simulated.[xviii] At the higher education level the OpenCourseWare from MIT and other institutions around the world provide a rich source of materials for studying complex issues.

I would like to see other OER developed that challenge students in different venues and ways. This includes OER games, virtual spaces to explore, performance assessments, material for project-based learning, and tasks designed for teams on site together or via networks in many different places to work on jointly. The design and use of these open tools create areas for research. Note that not only traditional students will be able to use these materials if they are open—non-traditional students, retirees, and adults tired of watching television will all be learners, too.

Do OER improve attainment? I have argued that access and learning can be influenced by OER. Attainment (for example, whether a student attains a next grade or graduates) may also change. In many places, post-secondary students

already are able to study online at home or in a library where they have access to OER or other relevant materials—and then take an examination for credit.[xix] Open materials also make it possible for students to learn on their own schedules rather than on the schedule of professors appearing in two- or three-day-a-week classes. With the freedom of setting their own rate of learning students may find that they can accelerate through the content without loss of understanding. Perhaps in the future more students will take only two to three years to graduate from four-year colleges. Finally, the MOOCs and other open materials make college-level courses available throughout life to anyone with a computer. All of these changes will influence the way that we learn and the future of our learning institutions. Yet our research in these areas is skimpy at best.

Do OER that are adapted to fit local needs improve achievement and attainment? Up to this point in the discussion I have focused on the possible effects of intact OER on achievement and attainment. A second feature of OER is the right to adapt the OER to meet local needs. Arguably the freedom to adapt is a good one in and of itself—it empowers the users (students, teachers, others) to bring the product into better alignment with their needs, while the act of adaptation itself may serve as an important learning experience. However, we need research to determine whether, when, and how an OER adapted to meet the needs of a new population adds value for the new users. In the context of schools, we should explore effects both on students (motivation and achievement) and on teachers (perhaps satisfaction and new knowledge).

There is a prima facie case that adaptation (e.g., translating the content to address the language of the new population) improves access for new populations. But we also need to know whether the adapted OER is effective in the new setting.

Unless the adaptive change in the OER is very significant, such as translating the text to another language, the independent effects of the adaptation probably will be small. The size of an effect will likely depend on how much and how well the OER was altered and whether or not the new population was different from the original one that used the OER.

In most cases we imagine that a teacher or other adult will carry out the adaptation. Another approach might be to ask students in middle and high school to carry out the adaptation. We have some reason to believe from research on peer tutoring and group study teams that the effects on learning might be quite substantial. Strategies of this sort become possible with OER and deserve exploration.

The school environment makes the research especially challenging. The constraints of our school systems and the pressure for educational interventions to not be disruptive often allow only incremental changes, which make the effects hard to measure.

Small and big effects. Thus, even in the area of OER adaptation, many of the changes are likely to produce only a small effect on student achievement. Small effects are not robust—they vary with the environment and the population and even within a population. When studies are replicated, small effects often disappear entirely. The problem of small effects will persist in the field as long as we nibble around the edges of current approaches to curriculum design and teaching.

But there may be a bright spot. Many nibbles focused on continuous improvement of the same content may be very important! Although the effect of one nibble may defy detection, the effect of multiple nibbles that are all focused on a particular goal such as improving achievement might be powerful enough to create a big effect.

In contrast to nibbling, suppose we imagine that we could deliberately design an OER to have a "big effect." If we design an intervention that opens the door to really powerful improvements in effectiveness, then our research challenge gets easier, and, of course, our students learn more. OER already show very large effects in access made possible by their unique characteristics.

One hypothesis is that the more flexible and easily adaptable an OER is, the greater the possible size of the effect, because local users can more easily tailor the content to meet their needs. Making OER as flexible and adaptable as necessary to engage average users in the production might become a design characteristic.

This could open the door to engaging crowdsourcing of users (students or teachers) to help achieve the improvements.[xx] As we do we might consider various ways of defining large effects. For example students might be able to learn faster or learn more in the same time period and/or acquire deeper subject knowledge. Imagine, for example, that a professional network of teachers took up the challenge to create a full year course in high school algebra that could be learned by average students in one semester. In a year or two, the professional network collectively creates a product designed for accelerated learning. When piloted by some of the network teachers, the product has some problems that are corrected and the product eventually proves successful—final exam results show no significant difference in achievement between students who completed the course in one semester and those who took the full year. And, in tests six months later, the results show that the students had retained their understanding of the content.

In this example, the acceleration of learning created a "big effect." Another interesting project would be to dedicate research teams explicitly to designing open interventions that had the promise of creating very large effects.[xxi] Some of this promise might rely on the rights of the users to adapt the materials for their use. A variation would be to involve students as full participants in the design and development teams.

If we could create OER interventions that generate big effects, we would not have to rely on the rather arcane statistical and design approaches currently in use to detect small effects. Dramatic increases three years in a row by students in a dozen different schools who master algebra using a new OER algebra program may be viewed as compelling evidence, even though the study design does not meet the highest standards. Such a result should be convincing enough for people to try the program in other places.

Another reason to push for big effects is they tend to be more forgiving than small effects, which can disappear when the population or environment change. Think of big effects as robust! And the more robust the effect, the more likely it will remain in place when the OER is adapted for a new population.

In the long run, better product designs yielding large potential effects may be more persuasive and productive paths to demonstrate effective OER than highly structured randomized trials of existing products. The creation of big effect OER products and practices might also spur innovation from proprietary competitors. All of these conjectures merit further study.

The research challenges for this bucket are scattered throughout the text. One interesting one, in my view, would be figuring out how to fully engage networks of students and teachers to use adaptive and collaborative strategies to design OER capable of producing very large effect sizes. At the same time there is room for case studies in areas where sustained continuous improvement of an OER can move it from having moderate effects to having large effects.

Bucket D: Innovation—Investigations into New Ideas and Positive Disruption.[xxii]

The discussion of "big effects" is a good introduction to this section. Big effects might well be viewed as innovation. A crude definition of innovation is that it adds *new value* through products, services, technologies, or ideas to make an activity or system more effective or to solve new or old problems. Disruption may be a product of innovation and typically refers to a substantial deviation of an organization or practice from an expected path. There is no shortage of studies and blogs focused on innovation, along with a wide range of start-ups, many using technology in hopes of breaking into education markets. In their influential 2008 book, *Disrupting Class: How Disruptive Innovation Will Change the Way the World Learns*, Clayton Christensen, Curtis W. Johnson, and Michael B. Horn write about the disruptive impact that online learning courses might have for secondary school education.[xxiii]

Changes in hardware and software, the accumulated wisdom of practitioners, crowdsourcing, and research on learning and teaching may all lead to new ideas and possible innovation in education. Some innovations will catch on in schools and classrooms around the world. Formative assessment tools, ways of organizing presentations, tutoring programs delivered in video and back-office capacity in

areas such as data gathering are examples of ideas that have achieved wide distribution in the developed world and that offer promise everywhere. Only a few ideas in education technology, though, have been truly innovative, much less disruptive.

Because they can be adapted by users and others and are not bound by the constraints that many proprietary organizations have to generate profits and to not deviate much from well-beaten paths of users, an argument may be made that OER are more likely to become genuinely innovative than profit-driven education technology. This is not conventional wisdom, which holds that the profit motive, market place, and the greater resources of the for-profit sector will stimulate and reward more innovation. This disagreement cries out for systematic study.

The argument becomes more complicated with the possibility of marrying "openness" with the market. Linux arguably became disruptive when Red Hat made it truly available to businesses that lacked the technological capacity to use it without expert outside support. OER without NC (non-commercial) restrictions might benefit from dramatically increased usage if supported, perhaps augmented and promoted, by the private sector. This could easily happen with government-supported OER, which are in the public domain.[xxiv]

In earlier sections I discussed a number of OER that I believe deserve the labels "innovative" and "disruptive." Indeed, every OER that has gone to scale meets many of the criteria for innovation. MIT-OCW is an innovation and is viewed by some as a positive disruption. The advocates might reason that the prestige of the university and the breadth of its approach in opening up huge amounts of its instructional content for access, use and adaptation, led other universities all around the world to a new perspective about openness. Professors, students and other interested people across the globe now have continuous and unfettered access to the rationale and content of all of MIT courses. OCW does not stop at the boundaries of Cambridge. Spurred by MIT's example, well over 150 institutions from more than 60 nations have formed a network (consortium) and publish their own Courseware.[xxv]

The Creative Commons licenses have been innovative and disruptive in the creative arts, science, and education. Open Access has been innovative and positively disruptive. Wikipedia is innovative and disruptive. Where are the encyclopedia salespeople who used to come door to door? Khan and TESSA are innovative and Khan arguably has been disruptive. The Connexions platform was innovative in 2002 and is rewiring itself to be innovative through an emphasis on open textbooks in 2013,[xxvi] while Gooru's plug and play platform is close to becoming innovative now. [xxvii]

As with the challenges presented in the other parts of this paper, it is useful to look at the special characteristics of OER. Access level 1.0 is one step, Access level 2.0 is a second step. They both help a product or idea to become innovative or disruptive. But the potential giant of innovation and disruption is Access level 3.0, which allows the OER to be adapted by users to accommodate their unique circumstances.

Many observers argue that by 2018 the traditional landscape of the classroom will be different; altered by openness, crowdsourcing, professional networks, collaborative development, a growing attention to diversity, and some sort of connected equipment at every desk and in every pocket. The incidence of traditional paper and digital textbooks, fixed time to learn, and linear and rigid teaching and learning will be greatly reduced. Non-traditional learning will be greatly increased. Open and adaptive online learning and teaching materials will be easy to use, highly interactive, and personalized to the needs of students and teachers. Networks of teachers will have access to a wide variety of tools and the capacity to improve them for their classrooms. Students will have far more authority to work in groups, to explore, and to proceed at their own rate and to explore.

Even if the world has not made all of these changes, I expect a wide variety of innovations, some disruptive, to emerge from the Open space. Free online learning courses, fueled by the MOOCs, are already seeding serious disruption in the post-secondary sector. Fully *open* online courses, with plug and play platforms, may be the vehicles that ultimately accomplish Christensen, Johnson, and Horn's

predictions about secondary schools relying heavily on online courses in the future. The increasing likelihood that many students will be able to learn more material more quickly in carefully crafted and motivational online courses than in average traditional classrooms will create disruption as students challenge the concepts of an academic year, semester-sized bites of knowledge, and credit for seat time rather than academic performance. In the context of on-line courses we cannot overestimate the power of being able to review the presentation of material multiple times. Asynchronous lectures or other forms of presentation that are continuously available, ironically like books, provide individual students and students in groups the opportunity to immediately cycle back and test their understanding of the content being presented.[xxviii]

One byproduct of this disruption may lead to open courses being supported by private for-profit companies—the field's increasing understanding of the potential power of adaptation could alter the private sector's business models and its current position on openness.

Many advocates of OER also believe that, as teachers collectively realize they can modify open materials, schools themselves will become fertile farms for innovation. Teacher professional networks that create opportunities for crowdsourcing could be endlessly productive using OER to improve academic products, while networks that link OER and deeper learning could be very powerful. All over the world, teachers with common national curricula are now able to form professional networks via the internet. In the U.S., the adoption by over 40 states of the Common Core State Standards could accelerate this practice. All of the ingredients for bottom-up innovation are already in place.

Initially, a few teachers will engage in such efforts. The high levels of the demands of time and energy on most teachers and the lack of technology support initially will keep the numbers small. Over time, however, we should expect to see teachers more and more involved in using adaptation as a regular tool of their trade as hardware and software become more and more easily adaptable, and the power of networks becomes more evident and ubiquitous. To a significant extent, teachers will assume greater control over their work. Simultaneously, students will also

have new opportunities to control their pace and directions of learning. We have little evidence about how these two trends will interact, but it is certainly something that should be explored and tracked over time. Besides, I don't believe any other profession has seen its front-line actors dramatically modify its core work processes in the way that advocates envision for teachers. Wouldn't it be deliciously ironic if teachers were the first?

Finally, innovation by definition is something useful that has been unexpected. We should not underestimate the possibility that innovation arising from unique characteristics of OER can be used to help solve social and educational problems. Two of the characteristics of a solvable problem are that it has boundaries and that success and failure can be measured. One interesting challenge for a foundation would be to take a set of specific educational problems and see whether OER could address them.

How might OER address the costs and challenges that limit the kinds of laboratory experiences available to middle and secondary school students all over the world? How might OER help parents to work on reading with their children? How can the use of crowdsourcing by professional teacher networks help create a library of open learning materials for high school biology based on high-quality problems? How can we use OER to accelerate how 8th graders learn algebra?

How can we provide OER to students in schools without electricity or connectivity? Here is a problem that exists right now and for which OER have stimulated a set of strategies to address. The problem arises throughout the developing world in low-cost private schools or public schools that lack Internet access and electricity and often have untrained teachers. We find such schools in many nations including Kenya, Pakistan, India, and in the Syrian refugee camps. One approach to the problem might be to provide Khan Academy or other OER materials to support the work of the teachers. There are a variety of ways to make use of the OER materials. The content could be drawn from a memory stick plugged into a low-cost, credit card-sized Raspberry Pi computer and displayed by an inexpensive projector onto a screen in the front of the classroom. Power to run the computer and projector may come from solar panels or from human sweat, as

in a pedal-powered generator. This process circumvents common problems such as lack of Internet access and connections to an electrical grid, teachers' unease about their grasp of math, and the probable lack of availability of up-to-date textbooks.[xxix]

Another example comes from higher education. It is hard to imagine a network such as the African teacher education project, TESSA—in which universities share their understanding, methodologies, and materials related to teacher training—existing without OER.[xxx] Networks like TESSA and OCW Consortium (OCW-C) that engage like-minded people in sharing OER to help solve common educational problems appear to be an important by-product of the OER movement. The use and effectiveness of networks in increasing access and quality deserve research.[xxxi]

I believe that we must not underestimate the potential power of open materials to suggest solutions to problems that might never be discovered were we constrained to the use of proprietary resources. One research/analytic task might be to create a typology of conditions and uses where OER can be expected (or not) to play an important role in creating innovative ways to address important access problems. I understand that OCW-C is exploring this approach as a new part of its mission statement.

In summary, openness has been disruptive in government, software, research, music, and publishing, and shows promise of being disruptive in education as well. So far, the sources of disruption appear idiosyncratic—a faculty willing to share its knowledge, a Nobel Laureate with a strong desire to improve science education, an uncle wanting to help his niece learn math, a leader of a major Open University having an extraordinary commitment to openness. We need to understand better how innovation and disruption using OER has come about, and how they might be nourished in the future.

There are so many possibilities for research in this arena. I have mentioned a variety of issues that deserve research and action. The critical issues have to do with better understanding the social and technical environments that support useful innovation and disruption. The roles in the supportive environments of networks of

users, of crowdsourcing, and of the power of an OER being adapted for new circumstances all need to be studied. And, someone needs to keep track of what we learn about all this.

This suggests that some foundation or organization such as OECD or UNESCO hold a meeting every two years with the goal of producing a serious report on the relationship between OER and innovation and disruption, pointing out valuable new avenues of research and practice.

Bucket E: Beyond Formal Education: OER used in other domains.

Other than Open Access which is, in the words of Wikipedia, "the practice of providing unrestricted access via the Internet to peer-reviewed scholarly research," I know only a little about this area. The concept of Open Access has been around for a long time, but has grown with the Internet and began to explode around 2005. Measured by numbers of articles per year, it is on the upside of a J curve. The strengths and possible weaknesses of Open Access and its history are set out in a variety of places. [xxxii] I don't need to expand the discussion here except to suggest that we need continuing attention to the research on Open Access in the areas of quality and use of publications.

Public health and agriculture are two other sectors that exemplify the possibilities for the use of OER outside of traditional education.

For the past decade, the Public Health School at Johns Hopkins has posted OCW (now including over 110 courses), while Tufts University has created open courseware and other OER from its faculties of dentistry, general medicine, nutrition science and policy, and veterinary medicine. As part of its overall emphasis on OER, the University of Michigan has extensive OER in dentistry, general medicine, nursing, and public health. Teachaids.org is an open website originating from Stanford that makes free educational materials about AIDS available for streaming and free download in multiple languages all over the world.[xxxiii] All of these institutions make substantial efforts to insure that their content reaches the developing world.

A Pub-Med search for OER and Public Health came up with only a few citations in 2011.[xxxiv] However, all of the traditional OER metrics are on a steep curve and I suspect that the use of OER in Public Health is also climbing. A search of OER Commons for "Public Health" in April 2013 found 314 matches from all over the world. A Google search in December 2013 for "open educational resources" "Public Health" found 0.3 million references. [xxxv]

Agriculture is a core part of the OER Africa organization. A quick search on OER Commons found 614 matches for agriculture, matches again reflecting materials from all over the world.[xxxvi] A Google search on "open educational resources" "Agriculture" in December 2013 found 0.8 million hits.

It is legitimate to ask why we should separate OER into sectors like public health and agriculture. I guess the answer is to remind ourselves that OER has an extraordinary reach across many sectors. The use of openness and OER goes well beyond math and science and literature and history in our schools. The rise of smart phones and related technology has remarkably increased the ability of people all over the world to connect with each other for multiple purposes.

In light of this, the development and sharing of important and practical information in all sectors becomes necessary and inevitable. Organizations like UNESCO or the World Bank, which cross the lines of many occupations and professions, could promote research and consolidate and share information about best practices, new strategies, and the way that OER is used in these various sectors, particularly in the developing world.

Finally, at risk of appearing too ambitious, I would like to see OER leveraged to address pervasive problems not easily categorized into sectors, such as global warming, poverty, legal services, water scarcity, and the lack of educational opportunity in refugee camps.

On the research side we at least should have an ongoing project chronicling the use of OER in a number of key domains other than traditional education. [xxxvii]

Bucket F: Sustainability—Research on Business Models to Safeguard the Viability of OER Products over the Long Term.

I started this section intending to focus on the issue of how to sustain institutions that create and house OER, but I found myself also beginning to grapple with the issue of sustaining OER as a field, an issue that is considered in Bucket I. Both sets of issues are complex and difficult, and challenge the future of OER.

In a 2007 paper for OECD, David Wiley defined OER sustainability as "an open educational resource project's ongoing ability to meet its goals." He saw two parts to the definition. One is the "sustainability of the production of the educational resources," and the second is "the sustainability of sharing the resources."[xxxviii] The paper's treatment is thoughtful and useful. One strong insight pointed out the usefulness of incentives to support OER. The paper describes a number of the characteristics of technology and OER, and reflects on how those characteristics affect sustainability. Wiley also sketches a number of models for sustainability, drawing to some extent on earlier publications by Dholakai, et al, and Downes.[xxxix] I mention all of them below.

My treatment here is modest compared to these early papers and to two important articles from 2011. One was by Neil Butcher and Sarah Hoosen for the Commonwealth of Learning, "Exploring the Business Case for Open Educational Resources." Another by F. H. T. de Langen and M. E. Bitter-Rijkema was "Positioning the OER Business Model for Open Education."[xl]

Butcher and Hoosen suggest four models for support that do not require an individual or institutional benefactor: recovering funds saved through the use of open textbooks or courses; funding from governments, foundations, and scholarly communities for Open Access to academic journal articles; a subscription model similar to the one used by the Monterey Institute for Technology and Education (MITE) and SAKAI; and the creation of alternative accreditation or certification models such as credit for performance, where students use OER and then pay for passing certification assessments.[xli] They also note promising examples of

governments providing public funding for OER, not just by putting their materials into the public domain, but also by requiring some products of government funding to be given a Creative Commons or other such license.

De Langen and Bitter-Rijkema take a more radical approach. They link the idea of an OER business model to the sustainability of OER. They postulate that the *sustainability of the overall OER movement,* rather than of individual applications, depends on the construction of a business model that can serve as a "flight deck from which necessary OER-based learning activities can be launched." Their somewhat tentative conclusion is that "OER-based open learning networks" that engage in "social production modes of learning" constitute that "flight deck" and can, in the long run, sustain the idea of open education and OER. They see a future where there is a "shift from prescriptive education methods toward open learning formats and from monetary earning models toward a value network business model approach." These are provocative and important ideas—ones that deserve attention and probably funding to explore.

It seems to me that we ought to tread thoughtfully down both of the paths laid out in these papers. Until de Langen and Bitter-Rijkema's ideas come to fruition, the need will continue to secure resources to support and sustain OER applications. Both pairs of authors call for more research and study.

Currently, OER are supported by foundations (e.g., Hewlett, Shuttleworth, Open Society, Gates, Saylor, Arnold), higher education institutions (e.g., MIT, Athabasca University, OU-UK, Michigan, Tokyo, the University of South Africa), governments, and many individuals who give of their own time. Foundations will continue to support OER, but I expect less money will be designated for general needs like infrastructure development and maintenance, while more will go to particular projects such as a new and open Algebra course. Foundations generally will not commit ongoing support even for those activities they initially fund, often because they want to urge the leaders of the activity to be self-sustainable. For OER, the posture of the foundations that claim to be interested in innovation seems surprisingly near-sighted because the emphasis on self-support may constrain

innovation. A better criterion might be the quality of the work and the likelihood that the product will be effective.

Elite institutions of higher education will keep their existing materials up to date, but there is no guarantee that new material will continue to be made available. Other higher education institutions, whether publicly or privately supported, may not have the will or the resources to continue to sustain OER.

As a consequence of unreliable support, many advocates count on governments around the world to support and sustain OER by passing enabling policies and approving appropriations. Brazil, Vietnam, South Africa, Poland, the U.S., and the Netherlands are examples of countries that have helped to support OER by creating policies or by providing specific funding for new applications.[xlii] Creative Commons supports a wiki that keeps track of many of the government policies proposed or passed in various jurisdictions around the world.[xliii] Of course, this does not include the incredible amount of rich material placed on the web for free use under public domain license by dozens of countries, not to mention the content from government-funded enterprises such as the BBC and WGBH. In addition, many countries are explicitly promoting Open Access for research supported by public funds.[xliv]

As with any solution, government funding has its strengths and weaknesses. In the U.S., for example, the OER resulting from recent grants from the Labor and Education departments appear unlikely to receive continued support from the government for improvement or updating.[xlv] This may be because the government has not caught up with the adaptive features of OER, and the need for continuous improvement of a product. It may also be because the existing publishing community would oppose the action.

In one of her last acts at the State Department, former U.S. Secretary of State Hilary Clinton personally announced an initiative to create a library of open textbooks in both English and Arabic.[xlvi] At this time the initiative remains in the planning stages and issues of sustainability have not yet been addressed; but, as openness becomes more prevalent across cultures, I expect more such moves.

Actions such as these may have the potential to be disruptive. Logically, for example, it seems as if we might be just a few small steps away from making all public education materials open to all users (within and outside the school system) for use, reuse, and revision. Public coffers—usually those of states and districts in the U.S. and often the federal government in other countries—already support free textbooks and other curricular materials for K-12 students. Why not make them open to everyone— students, parents, teachers, public higher education, etc.? One big step, making the texts digital and free on the web for students and teachers, is already happening. The cost of a second step, providing access to the textbooks for everyone on the web, would be minimal. The economic and social benefits, however, could be considerable, especially to the developing world and to individual parents and learners. A third step would be to allow the open textbooks to be adapted to different environments around the world. The answer, of course, to the "why not" question is that such a policy would disrupt the current business model of commercial publishers, which to date rests on selling books. This approach would rely on governments, which, unfortunately, are sometimes fickle. [xlvii]

Perhaps a more robust system would include a mix of government and the not-for-profit and even for-profit private sector. Indeed, if there were more organizations, like CK-12 and OpenStax, committed to creating high-quality open textbooks, the commercial textbook publishers—like horse-drawn vehicles—might cease to exist in their current form. [xlviii] As we near that point we need to think hard about what will replace the existing business models. [7]

For OER materials that are not supported by government funds, the answer ironically may be to create a business plan that involves turning the open and free OER into market commodities in some way. This turns out to be more difficult than people have suspected. The examples from Butcher and Hoosen are only one

---

[7] Note that if such a scenario came about we also would need some rapid research to begin to understand the impact of the change – a particularly important question would be: would the change result in the improvement of the curricular and instructional materials in a meaningful way?

step. Even while some OER reach large audiences, people have not yet figured out effective business models to sustain them. Sal Khan has not had to face this issue yet, since he has been able to obtain foundation funds. CK-12 is supported by private wealth for the time being. The Hewlett Foundation supported the work at the Monterey Institute for Technology and Education with the challenge that it become self-sustaining. MITE tried a number of different funding models and ended up with a subscription model that applied a low cover charge per year to states. The revenue supported almost all of its basic activities. Flat World Knowledge moved away from a free model and is now charging for its product.

The Pearson Corporation is collecting OER that do not have a "no commercial use"(NC) in their license, including the PhET simulations, and combining them with its own products. It then offers these new products for sale on its user platforms. In theory, this action suggests a plausible model—a marriage of an innovative open product with the private sector. The model simply rests on the private sector actor (here Pearson) to provide a fair but modest compensation to the developers of PhET, perhaps based on sales of the product. This would allow the original creators to keep their OER up to date and to create new OER. It would be a win-win for creator and user. However, it is my understanding that, except for a very token amount from one department, Pearson is keeping the benefits of the OER simulations to itself.

Six additional funding models have emerged recently to complement the four identified by Butcher and Hoosen. They include compensation to OER developers for use of their materials by a for-profit entity (as in the Pearson example); a voluntary support or sponsorship model like National Public Radio; an endowment model like the one used by the Stanford Encyclopedia of Philosophy; a contributors pay model like the Public Library of Science (PLOS); a service model based on the Red Hat experience; and a model that rests on the backs of networks of users, such as that proposed by de Langen and Bitter-Rijkema.[xlix]

Future models might draw on the de Langen and Bitter-Rijkema vision of using a flight deck of OER learning networks to launch and maintain OER. Let us imagine a sustainable model of the following sort. Start with OER that allow adaptation and

are built by a university or other NGO, perhaps in collaboration with a local school district, and then used in the district. The materials are valued, nourished, updated and improved by a network of the district's teachers. As the reputation of the OER spreads, teachers in other settings join and contribute to the network by helping improve or elaborate on the existing OER materials. The creators would work in collaboration with the open learning network responsible for improving and sustaining the resources. OER that are planted in fertile soil may grow and produce fruit.

These materials could be open to the world. Candace Thille, now at Stanford, and Marlene Scardemalia, at the University of Toronto, worked together on a project for OLnet that explored some of the conditions that might support both individual learning and group knowledge building with OER. Understanding and promoting these conditions might enhance the development of collaborative models for sustaining OER.[1]

Networks, the wisdom of the masses, better platforms, and a growing and deepening understanding of the possible advantages of OER all will increase the odds of finding viable models for sustainability.

One penultimate thought: there is no reason for any particular OER to be sustained forever, even in modified form. Changing technology, new understandings about teaching and learning, and evolving demand will lead to new and different forms of OER. The same argument can be made about the institutions that create and curate OER. They, too, can be replaced, though some of the public institutions will have very long lives. The rules of creative destruction likely will hold in this sector as in many others, just as it should.

My conclusion from all of this is that we know far too little about the viability of models currently in place, but that, overall, the number of actual and potential models may be far greater than we have imagined and that the coming changes may be much more disruptive than we have imagined. Others see the world differently.[li] This suggests that more research on existing attempts to achieve sustainability and a great deal more imagination and creativity around these issues

may have considerable payoff. Maybe there should be an open competition for the best ideas and even prototype activities that might help reduce this problem.

Bucket G: Development and Improvement—Studies to Understand and Improve the Processes of Creating, Altering, and Using OER.

This section addresses questions about how best to design, develop, and improve OER. SRI International's report on the development of an evidence framework can help guide this work.[lii] While the SRI report is mostly on proprietary educational technology, it often refers to OER. Here is an area where OER developers and users can learn a lot from the work on non-OER education technology. Moreover, the nature of OER creates several new ways of supporting development and improvement.

A fundamental issue in development and improvement processes is how to effectively meet the needs of users. The traditional approach has been to design and develop on the basis of a clear vision and best evidence. Then, after carrying out some user testing with modest feedback, a final product is released. This linear approach often is used for state and federal government procurements, sometimes even for technology projects.

Rapid prototyping is another approach to design and development. Here the design process starts with a sometimes muddy vision and modest evidence and then depends on interaction with users for the bulk of its development. Users, especially small groups who are given instructions about what kinds of problems to look for, provide the grist for continuous feedback processes—they are engaged in reacting at all stages (vision, rationale, design, development, initial implementation) leading up to the release of the product and are heavily involved in the latter processes of improvement.[liii] Failure is expected at all stages and is even embraced, as it contains information and stimulates feedback loops for product improvement.[liv]

Collaborative development is a related methodology exemplified in open source software. It is commonly associated with the success of the Linux kernel and with crowdsourcing. Connexions, an open platform originally located at Rice

University, was designed and developed to assist in collaborative development of OER in an open environment.

On the research side of development and improvement, cloud-based platforms for online learning are now designed to allow creators of educational materials to gather massive amounts of data about how users behave while using the product. Data gathered though analysis of keystrokes, wait time, rate of progress through the material, and such can suggest areas where the program might be improved. With large numbers of users, the developers can randomly assign individuals to two different groups, one where the changes have been made and one where they have not. This form of A/B trial can operate as a true experiment and the effect sizes can be estimated. [lv]

Where do OER fit into all of this?
Changes in approach to design and development such as rapid prototyping affect the development of OER just as they affect other educational technology. But the possibilities for creative re-development and improvement are arguably greater for OER than for educational technology in general. Collaborative development, for example, is made for OER.[lvi]

If an OER has a license that permits derivatives, users are empowered (individually and/or collectively) to directly engage in adaptation and improvement to make the product meet their needs, or even to make a new product. Their role as users such as teachers or students shifts to that of creators when they translate content, provide new adaptive elements to make it more sensitive to the needs of their students, simplify the procedures needed to use the product, or merge the product into other products, creating something entirely new. Derivatives may become the engines of evolution.

Over time, users (students or teachers or schools or districts or states) could become curators of the "new" product. The crowdsourcing of the participants in teacher professional networks might produce extraordinary products. The feedback they supply might not come directly from keystrokes, but rather from direct observations of how students are learning.

More tools are emerging that provide support to users and collections of users to create, modify, and improve existing OER. Connexions is one such platform.[lvii] The Institute for the Study of Knowledge Management in Education's (ISKME) Open Author and Gooru are others.[lviii] Potentially, these tools will affect the way OER materials are developed, improved, altered, and used. But we know little about how much and how well this is happening.

More relevant to thinking about the "added value" presented by open materials is another set of research questions. When, under what circumstances, and how do users take advantage of the right to create derivatives? Do users actively try to improve the effectiveness of the OER they are using? What sort of product design best lends itself to easy modification by a technology novice such as a teacher in a typical school? What do we know about the use of various grain-sized improvements and adaptations? And do the teachers feed their changes back into their own community so that others may use their adapted materials?

The exploration of these activities may spur the creation of an environment where the processes for development, implementation (see next bucket), and continuous improvement are practically indistinguishable. These processes may come to be viewed by creators and users of OER as the new conventional way of thinking rather than as afterthoughts or anomalies. Such an environment might honor users, adaptation, and improvement rather than fidelity to an original static model.[lix]

Bucket H: Implementation—Studies of the Processes of Introducing and Using OER in Classrooms, Schools, Districts and Countries.

In many ways, the implementation of OER is similar to the implementation of proprietary, non-OER technology. From the perspective of teachers and students or other users who do not intend to adapt OER to their particular needs, OER and similar proprietary education technology are indistinguishable. For both, the strategies for effectively introducing new systems and training users vary with the nature of the technology, the local environment, and the characteristics of their classrooms.

Moreover, the processes are similar to rapid prototyping. The design and development work merge into implementation, perhaps with different actors, but with common goals to improve the quality of the product. Each addresses an uncertain future and often works in a very complex environment.

Yet, there are some general guidelines for the implementation and use of educational technology that are often useful. Users should have enough experience and training to feel generally competent with the material. The education technology must be as simple and powerful as possible and be perceived as appropriate and as adding value to the learning of the users. The teachers or others in charge of how the intervention is used must be willing to be flexible rather than rigid in the use of the materials. Implementing the materials in collaboration with partners, a team, or a network can provide great support to users. In general, the introduction of a new idea or intervention seems to work better in an organization that practices continuous improvement and learning.

Finally, the process of learning to use the materials effectively is not time-bound. Teachers can continue to improve their use of the technology intervention for a long time. Practice works.

These guidelines are relevant to the introduction of all Ed Tech, including OER. Still, we have to ask—what differences might we see in the implementation of an education technology application if the application carried an open license?

Let's go through the list of rights that may be attached to an OER to determine which, if any, might influence the process. The attribute of free to view might allow users in multiple places, such as in classrooms, libraries, or homes, to use the application. A similar proprietary application might be too expensive to be available in multiple sites. The permission to download, copy, and distribute will have a similar value of increasing access for all users. The permission to revise and adapt for specific kinds of students or environments could have a powerful and positive effect on the quality of the way the materials are used in many settings and could blend into existing modes of continuous improvement.

All of these attributes arguably could have strong, positive influences on the quality of implementation. They can and should be the objects of research—indeed, some have been or are now being studied.

On the potential down side, one attribute of many OER materials could impede effective use. Many applications built to be OER have been designed and made available without sufficient scaffolding to enable teachers and others to easily use them. In contrast, most commercial curriculum applications contain scads of scaffolding (at a price to the school systems). As OER applications become more plentiful and the developers and users become more aware, this problem may subside.

Another problem arises when a user has selected an OER application and put it to use in her school or university. The user may have extracted the OER from an aggregator such as OER Commons.[lx] After a while, the developer of the application updates it. Since the developer has no idea who is using the application, there often is no way for the developer to inform users about the updated version. Commercial companies do not have this problem since they are usually in contact with the user and require payment for the update.

This also could be viewed as the problem of sustaining a specific OER in the field. Who owns it? Who takes responsibility for updating it? The problem has two parts. The first, as previously mentioned, is the lack of a formal connection between the users in the field with the originator of the product. The second is the possibility that users will modify the OER to meet the needs of their specific populations. This could lead to many versions of a particular OER being developed by second level creators without other users knowing about it. All sorts of interesting innovation may be going on at the local levels without the user/creators having the means to make other users aware of it.

Although the circumstances are different, we might imagine that the same set of problems faced by users when the Linux operating system first became available. Businesses without skilled IT people could not make use of this open and powerful

tool. The Red Hat Corporation provided software modifications and support to companies that wanted to use Linux but lacked the technological skills to do so. A Red Hat-like proprietary organization that helped users implement OER might actually make enough money to support itself.

The ultimate implementation and use of OER requires that the potential user or organization have the capacity to be able to find the right application, trust in the quality of the application, and obtain support to continuously improve and sustain the use of the OER. Effective introduction and use of a product is tightly linked to the continuous improvement of the product and to its sustainability. OER appears to have a great potential advantage over non-OER in these areas because of the inherent capacity for improvement embedded in the right of users to adapt the OER to new environments.

All of this suggests that we should encourage more analysis and examples of good practice. Case studies of successful and unsuccessful implementation of OER may meet the need to draw together pertinent knowledge about this issue.

Bucket I: Infrastructure—Research on the Underlying Framework and Health of OER.[lxi]

The infrastructure that supports OER can be divided into two large parts—the first is the influence of the worldwide technical infrastructure supporting the use of technology. The second is focused on the health and growth of OER throughout the world.

OER is substantially influenced by the quality of the technical infrastructure and connectivity around the world and by the rapid increase and variation in platforms that deliver content. On the one hand there continue to be parts of the Global South and even parts of California that lack high-quality connectivity. On the other hand, the increase and variation in platforms offer opportunities for expanded use of OER. The need for high-quality open materials is arguably greater in the regions that have technically weak infrastructure than in more developed parts of the

world—this should increase our interest in research and innovation to use OER to meet the needs of people in the less advantaged areas.

Understanding the health and growth of the so-called "OER movement" may be more complicated. A smart person who commented on an earlier version of this document observed that there is an elitist ring to the term "the movement". I agree—the effort and labels must support inclusion, not exclusion. But the definition of "movement" is "a group of people working together to advance their shared political, social, or artistic ideas." This definition is a roughly accurate representation of the OER history for much of the first decade of the new millennium. In the early years, relatively few people and institutions knew of and supported the idea of OER. The Hewlett Foundation work in OER started with MIT-OCW as an opportunistic grant in early 2001.[8] Over the next two years, as we realized that MIT was not unique in its interest in sharing resources, we made a very deliberate attempt to build the field by building the infrastructure. We started by funding three more very prestigious universities to create the understanding to doubters that quality was important. Next we funded core organizations focused on openness such as Creative Commons and David Wiley's work at Utah State, and then high profile and high capacity international organizations such as OECD and UNESCO. Many other grants followed all over the world. Those given early were intended to signal that the effort was serious, and this attracted a lot of attention.[lxii]

Around 2007 or so, we began to think of the "movement" as "self-organizing." The left hand may not know what the right hand is doing but the hands trust each other. Yet even now, and even though we don't have a complete understanding about much of the use of OER throughout the world, it is still useful to think about the infrastructure needed to provide developers and users support.

A first step might be to set out a framework with some general structure and goals and then to figure out what indicators would be valid for determining how well the

---

[8] I joined the Hewlett Foundation on January 1, 2001 as the Program Director for Education. President of MIT, Charles Vest, came into my office in February, 2001 and presented his university's idea for OpenCourseWare. The Hewlett Board approved the idea at the next Board meeting. Later in the spring, Catherine Casserly, now the CEO of Creative Commons, joined my staff – first as a consultant and then as Program Officer for OER. When I use "we" in this section I am referring to Cathy and myself.

overall movement is going. A few of the indicators are obvious. One is a set of measures of growth, use, and quality. A simple growth indicator is the number of Google results searching for "open educational resources." In 2002 there were zero and today, in early December 2013, there are 13.8 million. Of course this indicator is flawed in all sorts of ways but it still carries a powerful message. Nonetheless, we need to become more sophisticated.

The Creative Commons' recent work on gathering data for growth and use indicators relating to their own internal goals might serve as an approach to emulate. Smart use of search engines to gather surface statistical data on use and supply could be a start. Perhaps we could use the "Wayback Machine" on the Internet Archives website to help create trend lines by providing data about the past. Another approach might be to use the various country and regional offices of Creative Commons, UNESCO, and the OCW-C to measure the growth of use and interest in OER on the ground all over the world. Other networks of OER creators and users, such as those organized by the OU-UK, could also help.

A second step might be to see if the various key components are healthy. Indeed, just figuring out what the components of the infrastructure are would be a useful task. Of course there may well be different theories of the operating infrastructure. This also would be important to study.

One component of the infrastructure is the core institutions. To start the discussion I suggest the following institutions as part of the infrastructure: the Creative Commons, OU-UK, OCW-C, MIT, COL, the Internet Archive, the Berkman Center at Harvard, Wikipedia, the Hewlett Foundation, Connexions at Rice, UNESCO, OECD, TESSA, the Shuttleworth Foundation, OER Africa, the European Commission, and the Institute for the Study of Knowledge Management in Education. These institutions all play different and critical roles. There are many other candidates and we need to recognize that some institutions that were central to the movement in the past no longer are, and that other new institutions are now becoming critical to the health of the movement.

A second component of a healthy infrastructure is networks. OER has loosely knit, but very active, networks of advocates and users across the world that share ideas and often see each other at international meetings. Perhaps the largest is OCW-C, with over 150 institutional members from over 60 countries. In addition there are networks, such as the important one Susan D'Antoni shepherded while she was at UNESCO, that exist for a purpose for a while and then are closed. The Qatar Foundation International is creating a new network around the provision of OER for Arabic readers. I mentioned earlier the Open Policy Network and GO-FN, the Global OER Graduate Network, the TESSA network and networks of local researchers being developed by IDRC. Another informal network includes the readers of blogs that frequently discuss issues of OER—the blogs of Stephen Downes, David Wiley, and Creative Commons are particularly useful.[lxiii] And there are yearly meetings held all over the world that highlight OER. However, even with all of these examples, I suspect that we have fewer networks than we need for a healthy worldwide movement. Moreover, many of the networks are highly specialized and are unlikely to persist.

Governments are a third component. It is critical to work with governments to have them support Open Access for research and to place government-funded resources in the public domain. The extent that governments create and carry out such policy is a crude indicator of the health of the movement. But it may be worth studying whether governments are effective and reliable enough to depend on them to help lead the movement. They have legitimate political concerns about changing their traditional conception of knowledge from privileged to open. And, by and large, governments follow, rather than lead.

A fourth component is the need for continuing study of the OER movement. The OLnet and the GO-GN stand out, and other contributors are listed in the early section of this paper. An important collection of research articles was published in late fall of 2013. Edited by Rory McGreal, Wanjira Kinuthia and Stewart Marshall with Tim McNamara as the Managing Editor, the book is titled "Open Educational Resources: Innovation, Research and Practice" and was published by the Commonwealth of Learning and Athabasca University, Vancouver, 2013. It has a great collection of articles and is appropriately open.[lxiv]

One body of new research might address whether the OER movement is moving toward sustainability without compromising its basic goals of openness and independence. De Langen and Bitter-Rijkema's idea about using open learning networks as "flight decks" from which to launch OER and sustain OER offers much food for thought. Another important area to study will be balancing top-down (governments and foundations) and bottom up (user networks) products, and ideas to insure that the voices of users are heard.

Other research questions critical to the health of the movement are: Are the Creative Commons licenses doing their job? Is there a lively group of critics raising issues? Are political battles being "won" and lost? Has the level of creativity in OER been increased? And is there a reasonable balance between the for-profit world and the open world as well as an understanding of the utility of each?

Over time, there have been multiple signs of success. Some reflect the broad reach of the idea. In September 2007, the Cape Town Declaration meeting was held and its statement of open education principles drew thousands of individual and group signatures from around the world. In 2012, UNESCO held a world congress that produced the Paris OER Declaration, which was approved on site by representatives of all 195 member countries. Other signs, such as the powerful reach of the Khan Academy materials and the OCWC, show the potential power of OER, while the large number of open start-ups gaining traction over the past few years is encouraging—including Gooru, CK-12 Foundation, and the Foundation for Learning Equality, just to name three that come immediately to mind. Another positive sign is the existence of significant movements that show a sustained, deep commitment to OER, such as the entire Open Access effort and the emerging discussions of open government and open development.[lxv]

Less than two years ago, the MOOCs entered the picture with extraordinary speed and energy. Their demonstration of the power of free, the first level of access, has been stunning. The MOOCs have had great success in attracting users and interest, supporters and critics. Their entry has been clearly threatening, if not disruptive, to

the general assumptions of higher education institutions. Suddenly, a wide variety of innovative strategies to deliver and give credit for courses have become open topics for serious discussion. Although few MOOCs will be "open" they are seen by many as at least first cousins of OER. One exception to the lack of "open" is the platform that edX will use, which will be open, thereby making it easy and free for any others to create their own MOOCs.

The relevance of the MOOCs to this discussion is that, while there are few published studies of MOOCs to date, there is a lot research being planned and started. Both MIT and Harvard have committed considerable funds to research on teaching and learning in the context of the MOOCs, for example. And just recently the Gates Foundation and Athabasca University have created a MOOC Research Initiative (MRI) to "examine the efficacy of early MOOC models for various learner audiences and in a wide variety of contexts."[lxvi] These studies may have direct implications for OER.

The identification of MOOCs with OER is viewed by some advocates of OER as a two-edged sword. On the one hand, they see MOOCs as providing great opportunity. On the other, they worry that the craze over the MOOCs will undercut OER efforts and lead people to not understand the potential of being able to reuse and adapt OER materials. I don't think this will happen, but exploring this concern would be an interesting research project.

There are other areas of concern to the general expansion of OER. Only a small number of foundations have provided regular support. This creates uncertainty in entrepreneurs who need to see the possibility of long-term commitments. The larger concern, though, is the antagonism of the for-profit publishers, which is palatable and potentially a serious threat to expansion of the acceptance of OER by governments and other large institutions. It is possible that this threat will dissipate as the publishers develop new business models, but their legitimate concerns must include the possibility that their fate will be similar to the newspapers and bookstores.

This area clearly needs continuous smart attention and thoughtful research.

What needs to be done in the area of research?

I hope that the many people and organizations throughout the world that are interested in how OER might be best used to improve educational opportunity will find this discussion of research useful and provocative. If it could help stimulate new research, I would be delighted. There is a lot to be done.

But, this section is directed primarily toward the Hewlett Foundation, which continues to support the field of OER as well as to use OER to contribute to its major effort to improve and encourage the idea of deeper learning. The research that Hewlett has been funding at the OU-UK, COL, and other organizations has been and will be very useful. Still, I believe we need even more practical research to deliberately address core issues in some of the buckets that I have described.

1. I have suggested various ideas for research throughout this paper. Though they might benefit from context, it still would be useful to extract a list of the research topics suggested in the buckets. Then a specific task might be to co-fund, with two or three other foundations, a small (8-10 person) working group to sketch out a public research agenda for OER. The agenda would be opened to the field for comment and then updated every two years. The participating foundations and, possibly, governments would be urged to support studies along the lines of the plan. The agenda should be broad enough to have areas of interest for all sorts of creators, all sorts of users, governments, NGOs, and possibly the public.

2. In the meantime, to continue to understand the potential impact of OER on teaching and learning, perhaps Hewlett could team up with other funders to support three activities.
   a. Document the effectiveness (the degree, if any, of added value) of OER over time. This would include studies of the added value of all levels of Access as well as of the value gained through using the adaptation capacity of OER. Done well, this would include a wide range of research. One starting point might be with online courses at

the K-12 and post-secondary levels. Here the initial step might be to carefully examine the literature for existing studies. These don't need to be fancy, randomized design studies—we are trying to find general effectiveness defined as breadth of access and user outcomes. Courses from MITE, Khan, OLI, COL, OU-UK, CK-12, CA community colleges, open MOOCs, OU-Netherlands, OCW-C, and Saylor all are possible sources of existing studies. Part of this review would fully document whether and when savings result from open courses and textbooks.

b. Publish a report on the health and status of the OER movement every two years. This would be a 25-page report that presents the progress of the openness movement and OER in particular. Use the various OER worldwide meetings to discuss OER infrastructure.

c. Hold two OER research competitions each year. One would focus on an open call for research on a core question, as defined by this and other papers and by the researcher(s). The second would be a competition focused on developing innovative solutions to important problems, such as providing education to Syrian refugee camps or exploring how we might obtain a very large effect from the adaptive capacity of OER for teaching. The latter might spur networks of teachers and possibly students or other "crowds" to participate. The financial incentives do not have to be high.

I suggest that Hewlett's currently modest role in OER should be extended over the next eight years. Hewlett would support OER, convene OER meetings, explore the effects of OER policies, fund syntheses and analyses of research, create essays and opinion pieces on OER for publication, run interesting competitions, and make sure that fundamental parts of the infrastructure stay alive and well. Perhaps other Hewlett programs, in addition to Education, could tap the potential power of OER.

Over the next eight years I urge other philanthropies to become more involved with OER. The opportunity to use OER to stimulate innovation and to help solve problems around the world should belong to all of those who worry about

the plight of education, public health, food and water, particularly in the developing world. OER is a tool for providing the most valuable commodity in the world—information—to those who otherwise would not have access to it. There are few better ways to start closing the gaps between rich and poor and north and south than to use OER creatively.

Eight years from now, OER will reach its 20th birthday, an adult age. Its growth in capacity and quality will never end. But, by 2021, if the momentum we now have is maintained, OER ought to have attained the status of a useful, sustainable, and powerful tool for bringing knowledge and content to all people around the globe who are interested in learning and teaching.

End Notes

[i] The [William and Flora Hewlett Foundation](#) defines OER as "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 and 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."

[ii] "Unleashing the Potential of Educational Technology", Sept. 16, 2011. Executive Office of the U.S. President, Council of Economic Advisers. http://www.whitehouse.gov/administration/eop/cea/factsheets-reports/educational-technology

[iii] See page three of report in endnote ii.

[iv] Perhaps we might be seeing the "productivity paradox" in educational technology. It took years for productivity benefits to show up in the statistics of firms that were spending huge amounts on computers in the 80s and early 90s. During that time technology was used to speed up current processes. A major factor in the movement from small to larger increases in productivity was the development of the understanding that technology can not only improve current

practice, but also make new and more effective practices available. These practices were then integrated into the daily work of the firms. Education technology may be following the same pattern.

v See www.**olnet**.org See also http://ci.olnet.org/

vi See http://creativecommons.org/, http://www.col.org/Pages/default.aspx, http://www.idrc.ca/EN/Pages/default.aspx, https://open.umich.edu/, http://www.johnhiltoniii.org/articles/

vii This description is drawn liberally from the OLnet year 1 Narrative Report on Hewlett Grant #2008-3359.

viii The OER Research Hub is at http://www.open.ac.uk/about/open-educational-resources/oer-projects/oer-research-hub

ix See the University of Michigan open education site https://open.umich.edu/

x See (http://portal.ou.nl/en/web/go-gn).

xi OLnet's Year 3 narrative Report for Hewlett Grant #2008-3359 has a list of ten key challenges for the OER movement, which originated from the OER Evidence Hub. These challenges mesh nicely with the nine buckets used in this paper.

xii See http://www.poerup.info/ Also Carolina Rossini at the New Americas Foundation and Cable Green at Creative Commons are heavy users of the oer-advocacy-coalition@googlegroups.com to keep the OER community up to date on various policy activities around the world. See also the open policy network at http://wiki.creativecommons.org/Open_Policy_Network and the OECD paper at http://www.oecd-ilibrary.org/education/open-educational-resources_5k990rjhvtlv-en.

xiii The OER white paper has the same conceptualization in different words: "free" refers to free or gratis access to a resource. "Open" refers to free access in addition to the legal rights to reuse, revise, remix, and redistribute a resource. https://oerknowledgecloud.org/sites/oerknowledgecloud.org/files/11%2005%2006%20HEWLETT%20White%20paper.pdf OLnet has been supporting research on "Reuse" led by Andreia Santos and Chris Pegler. See for example Pegler, Chris (2011). *Reuse and*

Repurposing of Online Digital Learning Resources within UK Higher Education: 2003-2010. PhD thesis The Open University.

xiv For an interesting analysis of how to think about MOOCs see http://mooc.efquel.org/a-new-classification-for-moocs-grainne-conole/ Grainne Conole is a professor of learning innovation Leicester University.

xv See http://www.johnhiltoniii.org/articles/ and http://opencontent.org/blog/archives/2686 for a start. See also http://www.uic.edu/htbin/cgiwrap/bin/ojs/index.php/fm/article/view/3972/3383 for a more extensive document on community colleges.

xvi William Bowen's randomized studies, and the Carnegie Mellon Online Learning Initiative studies, show generally positive or equivalent effects for online learning compared to learning in traditional classrooms. See http://mitcet.mit.edu/wp-content/uploads/2012/05/BowenReport-2012.pdf and http://www.sr.ithaka.org/research-publications/barriers-adoption-online-learning-systems-us-higher-education. Also see http://oli.cmu.edu/get-to-know-oli/see-our-proven-results.

xvii See http://phet.colorado.edu/en/research

xviii See http://mw.concord.org/modeler/

xix Ten years ago, Western Governors University (WGU) publically aired the idea of credit being awarded for academic performance rather than seat time. Now WGU is considered the forerunner of an acknowledged disruption. See http://www.wgu.edu

xx See http://firstmonday.org/ojs/index.php/fm/article/view/1289/1209 and http://www.benkler.org/Benkler_Wealth_Of_Networks.pdfother

xxi A related, real-life example appears in a randomized study involving an OER carried out at Carnegie Mellon. The class of students using the OER was allowed only half a semester to learn first-year statistics, while another class had the entire semester. The accelerated class outscored the full semester class on end-of-term tests. See M. Lovett, O. Meyer, & C. Thille. (2008). "The Open Learning Initiative: Measuring the effectiveness of the OLI statistics course in accelerating

student learning." *Journal of Interactive Media in Education*.
http://jime.open.ac.uk/2008/14

[xxii] OLnet helped support a special issue of the journal EURODL on "Creativity and OER" which appeared in very early 2012. See http://www.eurodl.org/index.php

[xxiii] Clayton Christensen, Curtis W. Johnson, and Michael B. Horn (2008). *Disrupting Class: How Disruptive Innovation Will Change the Way the World Learns*. McGraw-Hill, 2008.

[xxiv] This thought arose from a comment on an earlier draft by Neil Butcher. I think this is what he was saying in his comment.

[xxv] See http://www.ocwconsortium.org

[xxvi] See http://cnx.org/ and http://openstaxcollege.org/.

[xxvii] It comes as no surprise that OER, fueled by an ancient conviction that knowledge should be free and open to everyone and motivated by the idea of tackling problems in creative ways, are associated with many of the recent innovations in education technology. Making knowledge free to the world is a giant idea—it is not new. "He who receives ideas from me, receives instruction himself without lessening mine; as he who lights his taper at mine receives light without darkening me." Constrained by this technology, Thomas Jefferson was expressing a value, which in the 21st century became a vision and a reality for the whole world. For more context around this quote see
http://www.wired.com/wired/archive/2.03/economy.ideas.html

[xxviii] See http://jayorlin.com/images/tutoredvideo.pdf and
https://opencast.jira.com/wiki/display/OC/2010/09/15/Gibbons+Revisited+-++A+Comparison+between+Tutored+Video+Instruction+and+Distributed+Tutored+Video+Instruction

[xxix] See http://learningequality.org/ for an example of this kind of activity.

[xxx] http://www.tessafrica.net and http://www.olnet.org/taxonomy/term/274, a study by Pauline Ngimwa.

xxxi There are a number of evaluations of TESSA—for a recent look at TESSA see http://bulletintessafrancophone.pbworks.com/w/page/62716591/2013%20TESSA%20evaluation%20report

xxxii See http://en.wikipedia.org/wiki/Open_access

xxxiii See http://teachaids.org/

xxxiv http://www.ncbi.nlm.nih.gov/pubmed/21381480 also see http://www.emeraldinsight.com/journals.htm?articleid=1937263

xxxv The use of quotes around two phrases makes Google only identify sites that have both phrases fully intact. For more on Public Health and OER—see http://rsh.sagepub.com/content/131/1/38.long Also see http://www.emeraldinsight.com/journals.htm?articleid=1937263 or https://www.researchgate.net/publication/235281873_The_emergence_of_public_health_open_educational_resources?ev=pubfeed_dept. and http://www.campusvirtualsp.org/?q=en/what-are-open-educational-resources and http://academiclifeinem.com/open-educational-resources/

xxxvi http://www.oerafrica.org/agricultureoer/AgricultureOER/tabid/1466/Default.aspx See also http://www.oercommons.org/search?f.search=agriculture

xxxvii Judging from one comment by a reviewer there is at least one leader of the OER movement that might want to take on this task.

xxxviii See David Wiley, "On the Sustainability of Open Educational Resource Initiatives in Higher Education," OECD, CERI , Paris, France, 2007. www.oecd.org/edu/oer

xxxix See http://www.oecd.org/edu/ceri/36781781.pdf https://oerknowledgecloud.org/?q=oer_resource/author/116&sort=keyword&order=desc S. Downes (2007). "Models for sustainable open educational resources". *Interdisciplinary Journal of Knowledge and Learning Objects*, 3, 29-4

xl See http://www.col.org/resources/publications/Pages/detail.aspx?PID=421 and http://www.eurodl.org/?p=current&sp=full&article=483

xli See http://en.wikipedia.org/wiki/Open_access, http://www.montereyinstitute.org, and www.sakaiproject.org, and http://www.wgu.edu

[xlii] See http://www.poerup.info/

[xliii] See http://www.poerup.info/ There are ups and downs in government policies. The governor of Sao Paulo recently vetoed a policy supporting OER that had been presented to him by the city's legislative body.

[xliv] U.S. government "Open Access" statement by the President's Science advisor. http://www.whitehouse.gov/sites/default/files/microsites/ostp/ostp_public_access_memo_2013.pdf/

[xlv] See http://www.ed.gov/news/press-releases/us-labor-and-education-departments-encourage-applications-trade-adjustment-assis

[xlvi] See http://www.state.gov/secretary/rm/2013/01/203382.htm

[xlvii] See Mulder, F. (2013). "The LOGIC of National Policies and Strategies for Open Educational Resources." IRRODL, Vol. 14, No 2, pp. 96-105. This is a somewhat different discussion of some of these issues.

[xlviii] Cengage, the second largest publisher of postsecondary materials recently went bankrupt, the latest of a rash of publisher bankruptcies. http://www.bloomberg.com/news/2013-07-02/cengage-learning-files-for-chapter-11-bankruptcy.html

[xlix] For the Public Library of Science see http://en.wikipedia.org/wiki/Public_Library_of_Science. For the Stanford Encyclopedia of Philosophy see http://plato.stanford.edu/.

[l] OLnet Adjunct Final Narrative Report for the Hewlett Foundation, page 1.

[li] Fred Mulder, on reading an earlier version of this paper, made a comment about this bucket: "I have a problem with the treatment in this bucket, which is diverging into multiple directions, many of them under the responsibility of the institutions. We could, however, take a more fundamental view, witnessing the current educational system as a whole to be not sustainable (high prices of books, increasing tuition fees, need for widening participation, enhancing lifelong learning, …). For which governments ultimately are responsible: they are to promote and ensure the accessibility, the quality, and the efficiency of education

and the educational system at all levels. Which includes to keep it sustainable. And it's easy to argue that OER and Opening up Education can contribute to this agenda. See, for example: *Mulder, F. (2013).'*The LOGIC of National Policies and Strategies for Open Educational Resources'. *IRRODL*, *Vol 14, No 2, pp. 96-105.* http://www.irrodl.org/index.php/irrodl/article/view/1536/2505.There is 'only' one strong counterforce, the publisher's anti-lobby, which we have to withstand .… They should realize that their business will not be any more about content but about services, a big change indeed but impossible to avoid." Neil Butcher followed up with the comment: "And that the coming changes may be much more disruptive than we currently predict (based on the premise of overestimating change in the short term and underestimating it in the long term)…."

lii See endnote xi. See http://www.ed.gov/edblogs/technology/files/2013/02/Expanding-Evidence-Approaches.pdf

liii The one exclusion of a significant body of users early in the process can arise when the basic vision is something very new— something transformative or disruptive. In one instance of this type of exclusion, the original product is designed for a special use for a limited set of users and then an idea for wider use arises from the more restrictive experience (e.g., Facebook). In these cases a larger body of users is brought in after the initial vision and basic design.

liv See "Rapid Prototyping" from Method and authored by Jeremy Jackson at http://method.com/wp-content/uploads/_10x10_download/3343-7a2dcf02.pdf

lv This area is receiving a lot of attention. Recently The U.S. Department of Education released for comment an SRI report, "Enhancing Teaching and Learning through Educational Data Mining and Learning Analytics." An earlier report by a committee appointed by NSF on CyberLearning contained a chapter on educational data mining. NSF has also funded a major center at the University of Pittsburgh and Carnegie Mellon to study this field. Coursera's Daphne Koller discusses this form of research in her TED talk in 2012. edX, the MIT, Harvard and Friends entry into the MOOC parade, lists research on teaching and learning as one of its three major goals. See http://www.cccblog.org/2012/04/10/dept-of-education-releases-learning-analytics-issue-brief/ http://www.nsf.gov/pubs/2008/nsf08204/nsf08204.pdf http://www.ted.com/talks/daphne_koller_what_we_re_learning_from_online_education.html

^{lvi} See http://cnx.org /

^{lvii} See http://cnx.org /

^{lviii} ISKME Open Author: http://www.oercommons.org/contribute/ and Gooru: http://www.goorulearning.org/gooru/index.g#!/home

^{lix} I am sure that some proprietary publishers are watching this research and applying similar techniques in their research. We may never know since they are as proprietary about their research and its findings as they are focused on their private returns. But it is possible that the mantle of openness, once donned in the use of open products such as the OLI and the Khan Academy, also will increase the odds that the private sector will begin to open at least some of its research and findings. At the least, if the open sector provides clear evidence of the effectiveness and value of OER, the commercial sector will have to provide evidence that makes them competitive. Openness may be contagious.

^{lx} See http://www.oercommons.org/   OERCommons is located at ISKME, the Institute for Studies in Knowledge Management and Education. See http://www.iskme.org/

^{lxi} See Smith, M.S. and Wang, P: The Infrastructure of Open Educational Resources: Educational Technology vol. 47 Number 6 November – December 2007, www.nx.org/news/BurrusEdTecArticle.pdf

^{lxii} For an independent review of the first years of OER at Hewlett see http://www.hewlett.org/uploads/files/Hewlett_OER_report.pdf.

^{lxiii} http://www.downes.ca/index.html and http://opencontent.org/blog

^{lxiv} Download the book at http://www.col.org/PublicationDocuments/pub_PS_OER-IRP_web.pdf.

^{lxv} For a review of open access (OA) by a leader of the movement see http://legacy.earlham.edu/~peters/fos/overview.htm and from an organization supporting OA see http://sparc.arl.org/issues/open-access. For a discussion of the emerging field of "open development" see "Open Development: Networked Innovations in International Development" (edited by Matthew L. Smith and Katherine M. A. Reilley), The MIT Press (January 17, 2014), Cambridge MA **ISBN-13:** 978-0262525411.

[lxvi] See http://www.moocresearch.com/research-initiative/about.