Research on Open:
OER Research Hub Review and Futures for Research on OER

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Contents

1. Introduction

Open Educational Resources: "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"

(William and Flora Hewlett Foundation)

The use of Open Educational Resources (OER) is increasingly being recognized as one of the most significant educational movements thus far in the 21st century. The *NMC Horizon Report: 2013 Higher Education Edition*, for example, counts it as the top Key Trend in terms of likely significance for higher education from 2013-18: "Openness—concepts like open content, open data, and open resources, along with the notions of transparency and easy access to data and information—is becoming a value" (Johnson et al., 2013). Adopted at the 2012 World Open Educational Resources Congress, UNESCO's 2012 Paris OER Declaration calls on governments around the world to adopt policies and support capacity development to promote the use of OER (UNESCO, 2012).

Intuitively, the idea of OER is attractive, particularly for learners with limited financial resources or systems with limited access to localized educational resources. But how much do we know about the efficacy of these resources or the types of use and adoption models that are most productive?

Since 2002 the Hewlett Foundation has been an important driver in the movement toward high-quality free and open content, and has funded a wide assortment of major programs in OER development and research. This report focuses on one significant investment within that portfolio: the OER Research Hub (OERRH), based at the Open University in the UK.

The OER Research Hub was funded in September 2012 with the goal of furthering research on OER, by conducting, supporting, synthesizing, and disseminating research on the impact of OER on learning and teaching practices. At that time, a number of strong OER offerings had emerged and were continuing to mature, including repositories such as ISKME's OER Commons, complete electronic textbooks from Rice University's OpenStax, and PhET simulations for science and mathematics, but research on OER was still nascent.

This evaluation report looks at the specific accomplishments and challenges of the OER Research Hub in the context of the broader field of OER research: where it stood when the research hub was funded, where it is today, and questions that are important for OER research to tackle moving forward.

2. About This Evaluation

In September 2014, the William and Flora Hewlett Foundation engaged SRI International to review its investment in the OER Research Hub. The review focused on the accomplishments and challenges of OERRH, the value delivered through its work, the role it plays in the global OER research community, and recommendations for the future of OERRH as the landscape of OER and OER research continues to evolve.

The evaluation used an assortment of methods:

- To understand OERRH's goals, work practices, and products, we visited the team, interviewed team members, examined reports and other information they provided, analyzed their online presence (the OERRH website and Evidence Hub) and conducted web searches on OERRH dissemination products.

- To understand the perspective of the partners that worked with OERRH, we interviewed 8 OERRH research fellows and other representatives of partner organizations.

- To put the work of the OER Research Hub in the context of the broader needs and offerings of the OER community, we interviewed 10 additional experts in OER and OER research who represented a variety of backgrounds and roles in the community.

This report summarizes the results of the evaluation, and draws implications for future needs in the field of OER research. The next section describes that field, with a focus on where it stood at the time the OER Research Hub began its work in 2012.

3. OER Research: The Lay of the Land

The last decade has seen significant growth in the availability and organization of open educational resources and, in turn, a growing volume of research on OER. In the annual survey-based report on online learning in higher education that the Babson Survey Research Group has conducted since 2003, the topic of OER has been included since 2009 (Allen & Seaman, 2011). In addition, a growing number of OER tools and platforms have been the subject of strong academic research (for example, Concord Consortium's Molecular Workbench; the University of Colorado Boulder's PhET simulations; Carnegie Mellon's Open Learning Initiative). As of early 2015, the OER Knowledge Cloud (https://oerknowledgecloud.org/), a repository of research related to OER, had over 1,000 postings.

Yet the majority of research on OER can be characterized as exploration, description, or advocacy rather than controlled empirical tests of efficacy. While many acknowledged progress in the last few years, some of our interviewees that are well acquainted with the OER research field described it as "not as developed as it needs to be," "early stage," and "polyanna" (telling stories of the positive, without presenting a balanced reality). Said one interviewee of the relative lack of strong empirical research, "So much is still opinion."

To test this claim, we analyzed a total of 78 OER-related articles that were published between 2012 and 2014 in the International Review of Research in Open and Distributed Learning (IRRODL), a prominent open journal in the OER field. Coding classified the articles into categories as shown in Table 1:

Table 1. Study Types

Category	Description
Impact study	Experimental or quasi-experimental study of OER outcomes, with comparison group
Empirical study	Study that includes outcome data, but lacks a comparison group
Implementation study	Study focusing on implementation practices or how OER is used in particular settings or across settings
Policy study	Study focusing on OER-related policies in place in one or more settings
Other articles with no empirical outcomes	Published articles that offer a theory, history or position, or that describe interventions or technologies, rather than describing empirical research

Across the three years, the highest number of articles (33) was in the final category, representing publications that were not empirical research, followed by 28 studies of implementation, and 12 empirical studies without comparison groups. Only two impact studies—outcome research with a control condition—were published in this journal during the three-year period from 2012-14.

Across the three years, in this admittedly limited dataset, some maturation of research content and method is evident. The trend lines in Figure 1 show a reduced number of OER articles with no empirical outcomes and a growing number of implementation studies over this timeframe, suggesting increased interest in investigating specific conditions and parameters of OER use.

Figure 1. Frequency of OER Study types in IRRODL, 2012-14
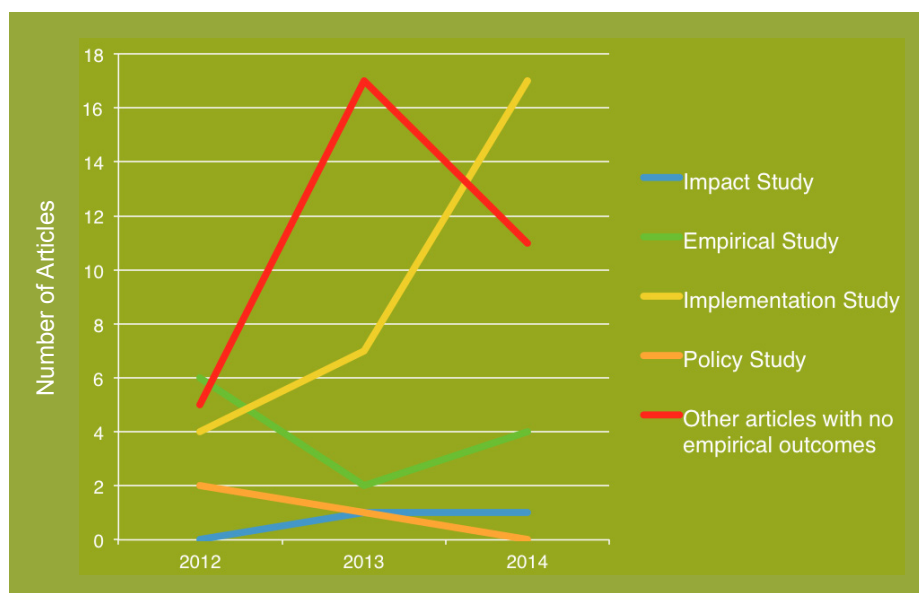
A more comprehensive review of the literature was published by the Open Education Group in 2015 (Hilton, 2015), suggesting similar trends. The review selected for empirical studies of OER efficacy in which the outcomes of OER learning resources were compared to traditional learning resources, and which were published in peer-reviewed journals. A total of nine efficacy studies were identified; of these, 8 were published in 2012 or later.

It should not be surprising that the field of OER research is taking some time to mature. Many of the fundamental attributes of OER make it a challenging target of traditional research designs. For example, efficacy studies rely on controlled conditions, yet the very nature of OER—the ability of its users to remix and adapt content at will—makes comparison of similar and defined conditions difficult to achieve. While it is always important to study efficacy in the context of implementation, with OER this is doubly true, as adaptation and implementation can change not only the effectiveness of the product but the product itself. This in turn adds complexity to the research task.

Another challenge to OER research is lack of consensus, both among researchers and practitioners, about what exactly OER is. Survey results suggest that many faculty members and chief academic officers are unsure what OER is (Allen & Seaman, 2015). The most recent Babson Research Group faculty survey found that two-thirds of faculty are unaware of OER (Allen & Seaman, 2015, p. 29). Even among those who are more conversant with OER, understanding of the term has varied. Some level of ambiguity is inherent in the fact that so many different kinds of things—ranging from course syllabi to small learning objects to entire courses—fall into the category of educational resources.

But there is also a lack of awareness and in some cases a lack of agreement about the necessary and sufficient features qualifying an educational resource as "open." Many people focus on the "free to use" aspect of open resources (although some OER definitions take a somewhat broader view, including resources offered at very low cost). Permission to adapt and repurpose the educational resource is missing from many stated definitions of OER. Furthermore, awareness of IP issues varies quite a bit around the world; in some settings the idea of restrictions on permission to adapt is foreign. Whether or not this feature is considered essential to qualify as OER has a major effect on what's in and what's out of the category. Some digital resources, such as Carnegie Mellon's Open Learning Initiative courses, are available to use for free, for example, but users cannot easily modify the content (Bacow et al., 2012; Griffiths, 2013).

An implication of the widespread lack of familiarity with the term OER and its definition is that respondents to surveys on OER may have very different referents in mind as they answer questions about topics such as OER's benefits, effectiveness, and drawbacks.

Another byproduct of the OER term's low profile is that empirical research on instances of OER can be hard to locate. In some cases, the particular product (e.g., the Khan Academy, the OLI Statistics course, or Phet simulations) may be more widely recognized than the term OER. If the research is not focused on some aspect of OER that sets it apart from digital learning resources in general, researchers may not include the term OER in the title or abstract of their publications, or even mention OER at all.

A third challenge is that research that is specific to the characteristics of OER is uneven with respect to what characteristics are selected for focus. For example, researchers in many contexts have well established that free and unrestricted access contributes to the reach of educational materials, but the value added by a license that allows modification and adaptation—and the frequency and patters with which such licenses are exercised—remains an important target of future research (Smith, 2013).

When the OER Research Hub began their work in 2012, there was relatively little work that synthesized findings or coordinated priorities across groups of OER researchers, who were often independently engaged in working through the challenges of this new field. This state of affairs in OER research shaped the challenges the Hub took on, the tasks they chose to pursue, and the priorities that framed their work.

4. The OER Research Hub

The OER Research Hub is a 2-year program funded by the William and Flora Hewlett Foundation in 2012 with the goal of "research[ing] the impact of OER on learning and teaching practices" (OER Research Hub 2013), and of raising the profile and the quality of OER research within the field. Housed at the Open University in the UK, a leading center of distance learning delivery and research, and following on OpenLearn (a platform for OER courses at the Open University) and OLnet (a 3-year project to conduct and promote research on OER, conducted by the Open University in partnership with Carnegie Mellon University), the Hub was well positioned from its launch to serve as a central coordination point for research on OER.

OERRH activities and organization

Activities conducted by the OER Research Hub are designed to serve a number of different roles in the youthful OER research community described in the previous section. The OERRH:

- *Conducts research on OER that spans global settings.* This research is designed to address 11 hypotheses (see Table 2) identified by the OERRH, in collaboration with the Hewlett Foundation, as important questions to pursue. The primary research tool created by the OER Research Hub is a survey, modular in design to address selected hypotheses in each setting where the survey was administered, and disseminated primarily through research partnerships at a variety of organizations around the world.

Table 2. OERRH Hypotheses

1.	Use of OER leads to improvement in student performance and satisfaction.
2.	The open aspect of OER creates different usage and adoption patterns than other online resources.
3.	Open education models lead to more equitable access to education, serving a broader base of learners than traditional education.
4.	Use of OER is an effective method for improving retention for at-risk students.
5.	Use of OER leads to critical reflection by educators, with evidence of improvement in their practice.
6.	OER adoption at an institutional level leads to financial benefits for students and/or institutions.
7.	Informal learners use a variety of indicators when selecting OER.
8.	Informal learners adopt a variety of techniques to compensate for the lack of formal support, which can be supported in open courses.
9.	Open education acts as a bridge to formal education, and is complementary, not competitive, with it.
10.	Participation in OER pilots and programs leads to policy change at the institutional level.
11.	Informal means of assessment are motivators to learning with OER.

- **Works to build research capacity** among OER researchers. OERRH fellowships are conceived as a mechanism both for capacity development and for enacting research partnerships. Six "linked" fellows (each representing a partner organization) have visited the OERRH for approximately 2 weeks on average, to work on research projects they defined and to learn from the OERRH team and from other experts at the Open University. The OERRH has also hosted five "open" fellowships with more general research goals (for example, research on OER policy). Open provision of tools such as the OERRH survey template and ongoing consulting activities are other mechanisms for building research capacity across a wider range of organizations.

- **Supplements the research capacity of partner organizations** by consulting on design, supporting data collection and analysis, and otherwise serving as adjunct research team members for organizations that work in the OER space but have limited research capacity internally.

- **Compiles and curates a searchable database** of research on OER. The *OER Impact Map* included over 130 pieces of evidence as of December 2014 (including published or posted work accessible openly), organized by geography and relevance to one of the 11 key hypotheses. Figure 2, taken from the Impact Map, provides a visual depiction of the evidence that the OERRH is compiling for and against each hypothesis.

Figure 2. OER Impact Map synthesis of evidence for and against hypotheses
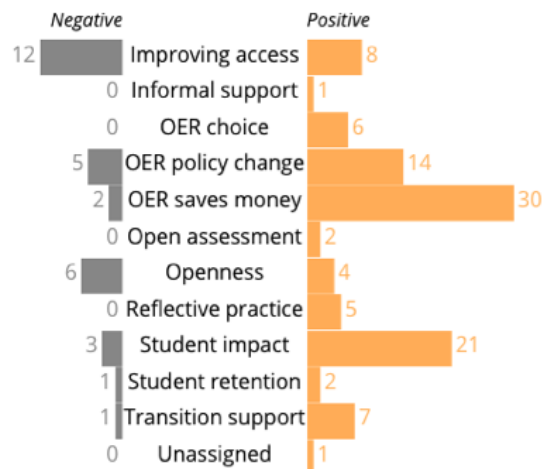
- **Disseminates OER research** through blogs, conference presentations, social media, online courses, and other means. OERRH team members and postings are broadly visible at key gatherings of OER practitioners and researchers.

Notable accomplishments

Among the set of functions carried out by the OERRH team, several accomplishments are particularly noteworthy and offer a foundation for the continued evolution of the organization. In this section, all inset quotations are taken from interviews with OERRH partners, fellows, and other collaborators.

The OER Research Hub has built a solid reputation among a community of OER researchers and practitioners as leader, expert, and role model. Consensus among collaborators suggests that the OER Research Hub is a go-to source for expertise and practice on open research. Across partner institutions, we heard common appreciation for OERRH advice and models, and common recognition of their leadership as conveners of a community of practice for OER research in a young field that otherwise lacked central coordination. To newer research organizations seeking to build international credibility and funding support, the "seal of approval" that comes with a partnership with OERRH is a valued contribution. The place of OERRH in the field is also evidenced by the fact that the group's leader has recently released a second book on the state of OER (Weller, 2014).

OERRH provides active support for less-experienced OER researchers seeking to engage in more significant research. While the OERRH team connects with researchers through a number of venues, the most direct collaborations to date have been with the OERRH fellowship recipients from partner institutions. Some of these participants are newer to research roles, or are the sole research resource within their organizations, and these individuals have benefitted from the guidance they receive from a team that they perceived as independent, objective, and experienced. A number of fellows described how much they learned from their interactions with the OERRH team and from other connections forged within the Open University that they would not have had access to locally (for example, new awareness of accessibility issues for learners with disabilities). For those in advocacy roles in particular,

"They're probably the world leaders in research on OER… No, not probably, actually."

"They've been unbelievably helpful to us because of their [respected position in the field]… Our credibility would have suffered had we not had their support."

"It was like a mini accelerator [for early career OER researchers]"

"When I approach people about open education, it's a different conversation. I have different questions to ask."

who have frequent conversations with educators and other OER users about OER benefits and resources as part of their job, working with OERRH has offered new perspectives.

OERRH has created tools to conduct integrated yet tailored research across national settings. The focus on 11 stated hypotheses, the development of a modularized survey as a common tool, and leverage of the OER Research Hub's system of partnerships has promoted an international research program that operates in the Global South as well as the Global North. OERRH team members work with partner organizations to interpret survey findings and to tailor research designs to address issues of local importance. For example, partners are able to see differences in what drives OER adoption: in South Africa a primary issue is filesize for accessible download, whereas in Western countries quality is more likely to be an issue of focus.

Tensions and challenges

The OER Research Hub also experiences a set of tensions and challenges that appear to have a moderating effect on the breadth of their impact. Many of these challenges are common elements of research on OER to date, and we offer them here as opportunities for continued reflection and evolution as the OERRH continues its work.

Tension between inclusivity and rigor. The OER Research Hub is deliberate and consistent in the openness of its practices and the pursuit of inclusivity as a principle. This contributes to their ability to serve as a voice and role model for "open," as described above. At the same time, it also contributed to some early design decisions that were in tension with the requirements of rigorous research that the William and Flora Hewlett Foundation hopes to promote. Two areas in which this tension have surfaced are outlined below.

- ***Survey methods.*** The OERRH survey described above has reached over 6,000 respondents to date through administration methods that are inclusive rather than controlled: educators and others served by the OER Research Hub's various partners around the world are invited to participate. While this method has promoted a wide diversity of respondents, it lacks a defined sample drawn from a specified population, resulting in findings that may or may not be representative of OER users and that are not generalizable. In the future, OERRH might consider more clearly defined sampling for each localized sub-study and procedures to manage/maximize response rates as appropriate in each context.

- ***Quality bar for evidence.*** Any curated repository of resources must make choices between inclusion of a range of inputs and selection of those that pass certain criteria. For the evidence selected for posting on the OERRH Impact Map, the main criterion is relevance to the focus hypotheses. The team chooses to include postings from a wide variety of sources in order to promote submissions from newer researchers as well as those who are more established. Research studies using different designs of vastly different quality are not distinguished from each other in the research review process or the Impact Map. As a result, users of the Impact Map must do their own work to

sort out issues of research rigor to determine whether to base decisions on what they find on the site. Given their strong status among collaborators, the OERRH team is well positioned to define metrics for rigor and other important research characteristics and to make these ratings transparent. This might serve two ends: it would allow users of the site to filter evidence according to their own research design quality criteria, and it would set a bar toward which newer OER researchers might strive to grow.

Audience-focused communication. The OER Research Hub's online presence and other communications are designed to be generic across audiences. Without specific audiences to focus and test communications, there is a natural tendency to generate communication designs that work better for internal than for external consumption. For example, users need to be familiar with the set of 11 hypotheses that drive OERRH's research in order to make best use of the Impact Map. It may be helpful for OERRH to consider the main audience for each communication of its work—for example, educators, policymakers, or researchers—and to tailor both the message content and the style of communication to that audience, an effort that OERRH is currently pursuing. User testing or targeted review of draft products is recommended for major dissemination products, like the Impact Map.

Identifying a focus for Hub research activities. When the hypotheses that drive the OERRH activities were initially devised in 2012, little work had been done in the OER research field to synthesize what was known and not known. In this context, it is not surprising that the OERRH list of hypotheses comprises a variety of issues but lacks a driving theme or framework. In some cases the hypotheses, and the research they are inspiring, do not distinguish among characteristics that are known to be important to clear understanding of OER (such as categories of OER that might be used in very different ways, like online textbooks, course syllabi, videos, or science simulations), or do not distinguish between the affordances of OER in particular and the use of online resources more generally. We recommend that the focus of future Research Hub activities be updated to represent unanswered questions about OER that are currently of high priority. The audiences that OERRH is currently defining would be a good source of priorities for research, perhaps using OERRH's extensive connections to field a survey that uses structured items to diagnose care-abouts and research needs of specific audiences.

We also foreshadow some important directions for future research in the final section of this report. Below, we summarize what we learned from interviewing OER experts about their priorities for OER research and lay out an initial framework to organize future OER research, including any next phase of OERRH's work as well as that of other research organizations that seek to inform our collective understanding of OER and how best to use it in a variety of settings.

5. Future Needs for OER Research

Given the current state of the field, this section will suggest productive avenues for future research to inform policymakers, educators and producers of open educational resources, in the context of supporting broader needs/challenges in education. This section summarizes the OER research needs expressed by experts as part of this study; presents classification systems for OER and for types of OER research studies; and makes recommendations for the curation, synthesis, and usability of a next-generation research hub.

What We Heard from Stakeholders

In the interviews we conducted, stakeholders articulated a diverse set of needs for OER research. For example:

- One overarching need is for rigorous, controlled impact studies to establish the learning and cost impacts of using OER, in comparison with other digital or more traditional materials, in a variety of settings. Stakeholders also called for a credible synthesis of available research in order to make the case to education policymakers that OER is a viable alternative to commercially published materials.

- Those who are already considering OER as an option seek research on the effectiveness of alternative OER products and studies yielding insights into how best to integrate OER into the broader context of their instructional practices and educational institutions.

- Those seeking to adopt some specific example of OER are looking also for research on best practices for implementation in contexts like their own.

- Funders considering investments in OER would like to see research focused on aspects of OER that distinguish it from other digital and nondigital learning resources—specifically, the ability to adapt and reuse it in different contexts. This leads to questions about what kinds of adaptations are made and whether or not those adaptations are, by and large, improvements over adopting OER as is.

- Policymakers interested in promoting the use of OER to increase access to education or reduce costs would like to be able to turn to research on policies that can encourage OER adoption and effective use. There are also broader policy questions such as whether in a situation where there is a major overhaul of education standards, such as the recent adoption of the Common Core State Standards in many U.S. states, schools and districts using OER find that they are able to adapt to the new standards more quickly than those dependent on commercial sources of instructional materials.

Notwithstanding the great diversity of views concerning the biggest potential contributions of OER research, there is general agreement that the level of rigor in OER studies needs to be raised and that OER research needs to move beyond thinly disguised advocacy if it is to attain credibility in the broader policy and research communities.

The examination of trends in the OER research landscape over the past three years in an earlier section of this report suggested that this is happening to some extent, but not quickly. One thing holding back progress, we believe, is the lack of a common, shared perception of what constitutes OER and the key variables that must be taken into account to make sense of different OER outcomes and costs.

OER Classification System

There is a great diversity of educational resources referred to as "OER." An open app to help students learn about a specific topic in middle school science will be associated with very different implementation issues, outcomes, and costs than an online textbook for a college seminar or an open system for course management. Nevertheless, many studies cluster such widely disparate instructional resources together under the heading "OER," making it difficult to make meaningful statements about use issues and value of the various types of tools. Aggregation of findings for such disparate kinds of OER is not very helpful to someone interested in a particular category of OER that may have impacts and implementation issues quite different from the OER average. To unpack this complexity, we recommend the use of feature codes to create more narrowly defined OER subcategories that can be used in planning and organizing research. Figure 3 suggests seven dimensions along which OER and OER uses vary, and a set of alternative features for each dimension.

Figure 3. Dimensions of OER

1 Level of Openness	(1) Free to use, but not modify; (2) Free to use, copy, distribute, modify, and incorporate into derivative noncommercial works; (3) Free to use, copy, distribute, modify, and incorporate into derivative works, including commercial works.*
2 Grain Size	Program/course sequence; whole course; unit of study; learning object; learning platform; assessment
3 Implementation Modality	Wholly online; blended with reduction in face-to-face (FTF) time; blended with no reduction in FTF time
4 Education Context	Early childhood; K-12 school; higher education institution; informal out-of-school
5 Learner Choice	Learner-selected; recommended to learner; required of learner
6 Subject Area	Humanities, language arts, mathematics, science, technical including programming, other occupational
7 Type of Learning	Procedural skills; declarative knowledge; deeper learning

These levels are a simplification of the four levels of OER access described in Smith, 2013.

SRI has used the last six of these dimensions in previous meta-analyses and syntheses of effectiveness data for technology-based learning resources and found that impacts vary by Grain Size, Implementation Modality, Subject Area, and sometimes Type of Learning (Means, Peters, & Zheng, 2014; U.S. Department of Education, 2010).

Types of OER Research Studies

In addition to having a classification system for OER, the field would benefit from a shared language to describe the major different kinds of OER research studies. In this report, we have used the following categories:

- *Impact Studies that Include a Counterfactual* (i.e., a comparison or control group for which outcomes are measured to show the results that would have occurred without the OER) and measure outcomes such as:
  - Student learning outcomes
  - Student motivation/socioemotional learning factors (SEL)
  - Teacher practices/motivation
  - Access to learning
  - Cost effectiveness (requires both learning outcome and cost data)

- *Empirical Studies that Measure Outcomes but Lack a Counterfactual* may look at any of the same outcomes as impact studies but lack the comparison or control group needed to estimate the impact of the OER.
- *Implementation Studies* examine the way in which OER is implemented and include case studies and comparisons of different ways of implementing OER.
- *Policy Studies* are descriptive studies of OER policies and policy changes without outcome data or quantitative data on implementation variables.

Studies of the impact of digital forms of OER should build on prior work on the impact of digital learning interventions. In fact, the digital learning effectiveness literature can be mined for OER examples since it contains studies of particular pieces of OER without necessarily explicitly using that term.

Based on our series of interviews with OER experts and our own experience in the digital learning research and evaluation space, we conclude that the greatest OER research needs are for:

- *Impact studies that incorporate meaningful control groups and objective, external measures of learning.* In the past, the few available controlled studies of OER impact have tended to compare the outcomes of students using digital OER to those of students using nondigital learning materials. Researchers need to ask themselves whether this is still the most pertinent question for policymakers. Certainly textbook publishers are incorporating digital resources into their commercial products. A challenge for OER developers is that commercial publishers now are making selected resources available for free, relying on "value layers" such as analytics and student data dashboards to generate income (Siemens, personal communication, November 2014). For many education administrators, then, the choice is not between OER and print textbooks but between OER and

the ebooks or learning software sold commercially. Generally speaking, commercial materials are professionally designed and go through some level of quality review, but rarely do publishers subject their materials to any rigorous evaluation of efficacy (Chingos & Whitehurst, 2012). In many cases, OER was developed using resources from foundations or government agencies, and these funders have been more likely than investors in commercial companies to require research on efficacy. On the other hand, the academic subject matter experts who produce OER do not always have formal training in learning science or instructional design—Sal Khan being a famous case in point. We predict that research that compares different types of OER, or compares OER to commercially available materials of the same type (grain size), will become increasingly relevant to decision makers.

- *Cost impact studies that combine cost and effectiveness data to estimate the cost per unit of a desired student outcome* (such as a 5% improvement in course completion rate). These studies should specify the level of openness of the OER involved because the ability to distribute and modify instructional materials will affect scaling potential, and hence cost per student. Cost studies should also be conducted with attention to realistic estimation of costs in the comparison condition: for example, in the absence of free alternatives, how many students are likely to buy a textbook at full price? Even though it is well known that many students borrow textbooks or purchase used textbooks at a fraction of the list price, some OER proponents do cost comparisons for promotional purposes that assume that every student in the business as usual condition pays for a new book (Smith, personal communication, November 2014). In addition, few studies consider the transaction cost for students who spend time searching for alternatives to the full-priced book.

- *Implementation studies focused on the features that distinguish OER from learning resources in general, such as adaptation and sharing.* Studies of OER adaptation, for example, could focus on the usefulness of adaptation tools being provided in platforms such as Gooru, and the vexing question of establishing principles or processes for distinguishing between productive adaptations of OER and "lethal mutations" (Brown, 1992) that seriously compromise content accuracy or the instructional effectiveness of the resource. Implementation studies focused on adaptation are especially important for more granular forms of OER that teachers and faculty mix and match. This capability has appeal to instructors who want to make a course their own, but also allows for poor uses of OER for purposes or learner populations they were never designed for. Educational research has stressed the importance of coherence among the elements of instruction (Brown, Bransford, & Cocking, 2000; Cohen & Ball, 2001), and one has to wonder how much coherence is attained when instructors are mixing and matching instructional resources from many sources.[1]

  Implementation studies are also essential in global contexts where availability of localized instructional resources is scant. OER offers an excellent opportunity to adapt quality materials to local contexts, but to date studies that provide guidance for such adaptations are few.

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1 Some researchers have touted the value of diversity of resources, with learning communities providing the organization (e.g., Mason, 1998), although achieving coherence through learning community activities is still not commonplace in most classrooms.

- *Policy studies that pioneer methods for estimating the long-term cost effectiveness of implementing OER at scale.* Given the fragmentation and local control within the U.S. education system, such studies would probably best be done in other countries where nation-wide or regional adoption is occurring. Such studies could elucidate the system-level infrastructure, organizational capacities, and policies that promote or impede successful scaling of OER. These studies could serve the needs of education systems of different kinds and levels—for example, a national ministry of education, a school district, or a community college system. As noted above for cost impact studies, policy studies should specify the level of openness of the OER under investigation.

  Particularly useful to policymakers would be studies that combine data on scaling over time with data on educational outcomes (such as course credit or degree completion) and empirically based estimates of costs. One of the defining features of OER is that it can be downloaded and used without paying a purchase or subscription price. But that doesn't mean that OER use is really without cost. A school's decision to adopt OER can entail significant costs for modifying the school's IT infrastructure and for training teachers how to use it. These costs should be incorporated into estimates of the total cost of ownership for OER just as they would be for commercial learning software. In addition, the opportunity to adapt OER to local needs comes with the cost of doing that adaptation, which might not be incurred when implementing a more "turnkey" solution.

  Policy studies should distinguish between "true" OER that can be remixed and modified (openness levels 2 and 3) and "quasi OER" (openness level 1) that is free to view and use but not modifiable by users or available for the creation of derivative products (the Khan Academy platform, many YouTube videos, and the first generation of xMOOCs would fall into this category).[2]

- *OER communities.* For OER to live up to its potential for continuous improvement over a lengthy lifecycle, a community of users must be actively involved not only in making adaptations but in sharing information around the effectiveness of those adaptations (Orr, personal communication). Understanding the elements of a successful community of learners built around different kinds of OER use and reuse is an important topic for future research.

Choosing an Appropriate Level of Rigor

While there is widespread agreement that OER research needs to move toward a higher level of rigor, there has not been a great deal of discussion of just what that means. One perspective on rigor, promoted by the Institute of Education Sciences in the U.S. and also supported by international organizations such as the Campbell Collaboration, treats the randomized controlled trial (RCT) as the "gold standard" for research quality. This standard is used by the What Works Clearinghouse (WWC), which was established by the U.S. Department of Education in 2002 to identify educational interventions for which there is rigorous evidence of effectiveness. Randomized controlled trials are difficult to implement in education settings, and implementing them well requires significant resources. The number of technology-based instructional interventions reviewed to the WWC and found to have research backing meeting this standard is still quite small (Means, Shear, & Roschelle, 2015).

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2 Finer distinctions can be made among different levels of OER accessibility; see Smith, 2013, for example.

Studies do not need to meet the gold standard for rigorous design to be useful, however. Outcomes in contrasting conditions can be compared at the student, classroom, or school level using quasi-experimental and correlational techniques with statistical control for any pre-existing differences between the two samples being compared. One can never be certain that all the pre-existing differences between members of the two groups that might influence the outcomes have been measured and controlled, but prior research in the field can be examined to identify variables of likely importance. Even the U.S. Department of Education, in its Investing in Innovation (i3) program, accepts multiple quasi-experiments with statistical control in lieu of a randomized controlled trial as evidence of effectiveness sufficient to qualify for the i3 competition for scale-up grants. The "impact studies" category used in this report includes both random-assignment experiments and quasi-experimental studies.

A more fundamental difficulty is the fallacy of treating the technology (or the fact that a resource was accessed online) as the intervention. We know that the same instructional resource can be used in quite different ways by different instructors and students, with resulting differences in effects. The impact found in a controlled study, whether an experiment with random assignment or a quasi-experiment with statistical controls, will be a function of the entire instructional system, including student and teacher behaviors, the way in which learning is measured, and any interactions among these factors and between them and the instructional materials. Thus, it is not uncommon for digital learning resources to produce positive effects in some contexts but not in others.

The problem is further exacerbated in the case of OER where even the resource itself may have been changed. How can we generalize from the impact found in a study of using a piece of OER in one context to other contexts where it is not only used differently but actually modified? For this reason, synthesizing impact studies may be more complicated for OER than for more stable digital learning resources.

The complexities of interpreting impact findings for OER do not mean that controlled studies are futile or that studies without any control or comparison group ("empirical studies without a counterfactual" in the set of categories used earlier in this report) are defensible ways to measure causal impact. However, when there is no comparison group and no estimate of what we would expect as outcomes for the learners who used OER in the absence of those materials, we have no direct way of knowing whether the participants' outcomes should be considered extraordinarily good, par for the course, or dismal.

Rather, the challenge of drawing generalizable inferences from controlled studies of OER suggests the importance of having many such studies to support systematic research syntheses. The multiple studies no doubt will have been conducted in different settings, with different implementation practices, and using different outcomes measures, but if all the studies describe the nature of the OER being investigated and the implementation practices and outcome measures used, similar studies can be clustered together, providing stronger, more generalizable evidence than any single study could.

An approach worth considering would be setting up and studying multiple implementations of the same OER, with instructor adaptations in some cases and not in others. This approach would involve networks of teachers or schools committed to working as a community to figure out the best way to implement the OER under study. The Pathways Project of the Carnegie Foundation for the Advancement of Teaching (CFAT) provides one model for how this might be done. This project and the Statway course it produced, which ultimately resulted in improvement in credit achievement through a developmental math program redesign that leveraged OER, is described in the "Research on OER Implementation" sidebar.

Although the overall average for Statway course completion was a dramatic improvement over the status quo, such findings did not pinpoint the aspects of the Statway course responsible for the effect. The OER courseware was only one component of a course that also included instructor-led activities and psychosocial interventions. In recent work with CFAT researchers, SRI analysts have found pronounced variability in course outcomes attained by different Statway instructors related to the ways in which they directed their students to use the courseware. The association between different instructor implementation practices and students' course success rates is currently being investigated, demonstrating one of the new approaches to evidence possible with digital learning systems (U.S. Department of Education, 2013).

Having this kind of data set from a substantial number of implementing institutions supports analyses relating practices to outcomes and would be very useful for other widely used examples of OER, such as the OpenStax textbooks. The

Research on OER Implementation: The Pathways Project

Carnegie researchers have been working with educators from two- and four-year colleges on the problem of getting students who come to college without the preparation needed for a college-level mathematics course into and successfully through a college-level math course. The project's stated goal was to double the proportion of developmental math students earning a college math credit within one year compared to the baseline level at each college. The colleges that CFAT convened agreed to collaborate with other colleges and with researchers and developers to analyze their developmental mathematics failure rates and then redesign their approach to developmental mathematics through collaborative development of a new course and associated policies. After conducting this analysis, the collaborators realized that many students were lost in the transitions between the multiple courses in the developmental math sequence, and that their existing developmental math courses were not very engaging. The partner colleges agreed to replace their series of separate courses with a single two-semester course emphasizing statistics and real-world problems. The result, called Statway, incorporated OER courseware for Introductory Statistics developed at Carnegie Mellon University (with Hewlett Foundation funding) into a blended learning course that also covered basic mathematics and included psychosocial interventions designed to increase engagement. In the first year of Statway implementation, three times as many students earned a college math credit in one-third the time compared with historical averages at the participating colleges (Strother, Van Campen, & Grunow, 2013).

research must distinguish between OER that can be modified by teachers/instructors (e.g., Stanford edX courses) and that which cannot (e.g., OLI 1.0 courses). The former category would be particularly appropriate for this model of research built around an improvement network of users seeking to refine the OER itself as well as to improve implementation practices.

Recommendations for Making Quality OER Research Broadly Available

Becoming the "go to" source of OER research is an ambitious goal, and the experience of the OERRH illustrates many of the barriers to its achievement. The difficulty of identifying all of the relevant research studies when many researchers do not use the term "OER" has been discussed above. Putting this challenge aside for the moment, there are other reasons for the difficulty of this task. It is one thing to build an online repository of research findings, and quite another to have people actually use it.

The What Works Clearinghouse of the U.S. Department of Education provides a contrasting case that helps to bring the scope of this challenge into focus. The WWC was established in 2002 specifically for the purpose of identifying educational interventions for which there is rigorous evidence of effectiveness. Usually these interventions are well-defined, and some of them have been specific learning technology products. Once an intervention has been chosen for WWC review, a systematic, well-documented process for locating studies and judging their quality is implemented (U.S. Department of Education, Institute of Education Sciences, 2012). Yet despite the federal investment of tens of millions of dollars and the hard work of highly trained WWC contractor staff assembling and vetting research studies, the General Accounting Office (GAO) found that practitioners make limited use of the WWC to identify evidence-based practices (GAO, 2010). A survey conducted by the GAO found that officials in only 42% of American school districts had even heard of the What Works Clearinghouse, and only an estimated 34% had ever accessed the WWC web site. Fewer than 5% of the 391 teachers and only about 15% of 208 principals surveyed by GAO said they had ever accessed the WWC. Districts that have heard of the WWC but do not refer to it frequently reported that they would be more likely to use the WWC if it included reports on interventions they were actively considering.

We see three prerequisites for a trusted and useful research hub:

- *Curation to insure the research is credible*

Research literature searches should specify their criteria in terms of research types and the kinds of outcomes a study must measure and report in order to be included in the research repository. SRI's meta-analysis of online learning for the U.S. Department of Education (Means et al., 2010), for example, limited the studies to be included to those using experimental or controlled quasi-experimental designs with objectively measured student learning outcomes for both treatment and comparison conditions.

Whether or not one agrees with the criteria for rigorous research used by the WWC (only randomized controlled trials can qualify an intervention as "effective" without reservation), the center has clearly stated

those criteria and the process whereby potentially relevant studies are reviewed and screened for inclusion (U.S. Department of Education, Institute of Education Sciences, 2012). Managed by Mathematica, the WWC has a large staff of individuals with advanced research degrees who must undergo training and become certified as capable of applying the WWC criteria reliably. Although it would have to operate on a much smaller scale, and perhaps aim for a more accessible bar, a research hub for OER should similarly state specific criteria for including research studies in its repository and have staff with the technical expertise to apply those criteria consistently. High-quality curation processes have associated costs, of course, and many organizations in the OER space have limited funds and have sought less costly approaches.

Originally, the OERRH had hoped to rely on crowd sourcing to identify credible research studies. This strategy yielded too few submissions, however, and did not really address the need for consistent inclusion criteria. One low-cost alternative would be to rely on the peer review processes used by some open journals such as *International Review of Research in Open and Distributed Learning.* For a research hub using this strategy to add value beyond that of the journals on which it would build, there would need to be multiple peer-reviewed open journals with significant numbers of studies of OER. The hub also would need to provide a user interface that was easier to use or provided more readable syntheses (see next subsection) than the journal indices themselves.

• *Synthesizing the research*

Once studies have been located and judged to meet the inclusion criteria for a research collection, a research hub should add value by synthesizing the research. As discussed above, the OERRH uses a "vote count" approach for each of its 11 hypotheses. Although this approach is widely used, it is considered a relatively unsophisticated technique for synthesizing findings of quantitative studies of impact. There are well-established methods for conducting quantitative meta-analyses that take into account factors such as sample sizes and variance in the outcome measures (Hattie, Rogers, & Swaminathan, 2014), although of course these rely on a base of quantitative impact studies of sufficient quality for synthesis.

The WWC approach to synthesizing research could be characterized as a variant of vote counting, with stated criteria for labeling the evidence for the effectiveness of an intervention as "positive," "potentially positive," "no discernible effect," "potentially negative," or "negative." The WWC approach is not without its critics (Stockard and Wood, 2013), and we do not recommend its approach for synthesizing OER research. But the point we wish to make is that the WWC does provide research syntheses made on the basis of carefully documented procedures and criteria.

Instead, we recommend that research hub staff use different approaches for the major types of OER research studies we identified above as important to the field. For learning or cost impact studies, research hub staff should synthesize research studies using well-understood quantitative meta-analytic techniques. For implementation and policy studies, qualitative synthesis will be more appropriate, but it is still important to specify the kinds of OER and the kinds of outcomes under consideration. For all of these types of synthesis efforts, analysts should specify the implementation models being considered in terms of education context, subject area, and modality.

This brings up the question of how broad the corpus of studies to be synthesized should be. Like "online learning" or "digital learning," OER is simply too broad a category to be associated with consistent research findings. As noted earlier, the WWC tends to restrict its syntheses to well-defined interventions (like Success for All) as opposed to broad categories like OER. For a few broadly implemented instances of OER, there may be enough research to start doing syntheses of comparable specificity. In addition, to inform future development and implementation of OER, we recommend conducting syntheses at an intermediate level of specificity, grouping together multiple OER examples of similar type used under similar circumstances (e.g., OER textbooks compared to commercial textbooks in lower division college science courses). Narrower categories for OER research syntheses could be based on features such as those in the seven OER dimensions presented earlier. We also recommend that once a category of OER is selected, the search for relevant research include use of the names of the most prominent examples of the category as additional search terms (e.g., search for "OpenStax" as well as for "OER textbook").

• *Making sure specific types of OER research can be discovered by interested parties*

Finally, we come to a challenge that has proven equally troublesome for the WWC and the OERRH. Educators interviewed by the GAO made the point that the only time they would be interested in using a research hub is when they are actively considering adopting some intervention that is reviewed in that research repository. In a similar vein, one of our OER expert interviewees made the point that OER research suffers from the same problem as does much OER—lack of use. He argued that potential users of OER research would not go to a research hub because of an interest in OER in general. Rather, they would be looking for OER research in the particular domains of their own teaching or research—be that engineering, the arts, or mathematics. In this respect, the usefulness of the current OERRH was limited by the fact that different kinds of OER were lumped together, making it difficult for the many different kinds of potential users to find what they were looking for. An alternative approach would be to use a coding scheme, something like the descriptors and OER dimensions presented above (but ideally determined through user studies to identify the most useful features) to tag each piece of research for an agreed-upon standard set of features. Use of tags based on such a standard set of feature codes would make it easy to filter OER research articles to find what you want.

This tagging could be done by an external organization curating OER research for a web portal or could be done by OER researchers themselves. The latter strategy would be more cost effective, but would be likely to have spotty implementation in the near term. However, working with academic journals that publish OER research to establish a set of OER feature codes as required key words or elements of the article abstract could promote researcher adherence to a common set of categories. Some academic journals (e.g., *Teachers College Record*) are now requiring a Structured Abstract with specific features for every article they publish, providing a proof of the feasibility of this cost-effective approach.

Using Research to Support the OER Movement

In conclusion, we believe that research can support the OER movement, but to do so the focus, quality, and accessibility of that research must improve. In 2012, the necessary critical mass of high-quality and empirical OER research was not available to serve as the foundation for a research hub that meets the vision we describe above. While raising awareness of the importance of high-quality research in the OER field was a driving goal of the OER Research Hub, the pressing need for OER research at this level continues. The need extends both to strong empirical research studies and to disciplined meta-analyses of particular subcategories of OER. We have suggested that OER research can be furthered most effectively through collaborative networks involving researchers and multiple OER implementers pursuing a common problem.

It appears that educational institutions and systems have a limited propensity to undertake high-quality OER research. Specific instances of frequently used OER may qualify for research funding from the EU's Horizon 2020, Research Councils UK, or the U.S. Department of Education's Institute of Education Sciences, to name a few. The broader issues of OER implementation and policy, however—issues such as a study of OER adaptation practices and their impacts or a series of meta-analyses of different kinds of OER—are unlikely to qualify for funding from agencies such as these. Philanthropic investment in OER research is likely to remain important to the OER movement for some time to come.

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