HISTORY, CONTEXT, AND POLICIES OF A LEARNING OBJECT REPOSITORY

by

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DISSERTATION ABSTRACT

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Learning object repositories, a form of digital libraries, are robust systems that provide educators new ways to search for educational resources, collaborate with peers, and provide instruction to students in unique and varied ways. This study examines a learning object repository created by a large suburban school district to increase teaching information and encourage collaboration among teachers. Despite investing nearly $2 million to develop the software and seed the repository with materials, data suggest that teacher use falls below set goals. This document explores five years of site traffic, user engagement, social interaction, asset growth, as well as the authoring of instructional materials as a means to evaluate the repository. The results of the study may inform the policy decisions of educational organizations when considering digital learning environments.

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CHAPTER I

INTRODUCTION

Technology has fundamentally altered the ways in which people communicate, archive information, and approach learning. Cutting-edge technologies such as smart phones, e-books, and streaming media have all but replaced their analogue components (e.g., land lines, print books, newspapers). Social websites foster online communities that are supplanting traditional forms of face-to-face collaboration, and social media are providing new avenues for consumers to not only access news, but contribute to it as well (e.g., Twitter, Disqus). Schools have started to adapt to this new technology as well. Learning object repositories, a form of digital libraries, are being created to house digital learning objects. Digital learning objects provide new ways to visualize and present instructional materials for both classroom and online learning. Learning object repositories provide educators with tools to not only author and store learning objects, they also provide teachers new ways to collaborate and share resources.

Digital repositories can be capital and labor intensive, however. Organizations that purchase or build these libraries may want to examine multiple measures as a means to evaluate design elements and policies: How often and when do members visit? Is use increasing or decreasing? Are users engaged? Are any value-adding interactions taking place? How much content is being added, who is adding it to the library, and why do some people contribute and others do not.

In this manuscript, I provide a review of the literature on learning objects, learning object repositories, and digital curation as the basis for a broad system of measures that can be used to evaluate Beaverton School District's TeacherSource repository. This document will (a) describe changes in the first five years of repository

traffic and user engagement, (b) examine asset growth, (c) user-generated social metadata, and (d) examine factors that affect authoring.

Early Conceptions of Digital Libraries

The concept of digital libraries can be traced back to Vannevar Bush's 1945 article *As We May Think* and J.C.R. Licklider's 1965 book *Libraries of the Future* (Harasim, 1995; Hauben, 2005; Singhal, 2001). Bush (1945) was worried that the depth and breadth of academic publications had far exceeded human abilities to process information and thus proposed a mechanized microfilm system, called a *memex*, that could store, file, and retrieve a wide variety of document types. This memex would store data by intelligent association, not alphabetically or numerically. Bush not only wanted to make data storage and retrieval more efficient, he envisioned that his system would ultimately facilitate additional academic collaboration and the dissemination of knowledge (Hauben, 2005).

Licklider (1965) later predicted that the entirety of written knowledge would be captured and organized into a repository of digital information. Content such as books, charts, data sets, and art would be coded with metadata that would be used to organize and retrieve it for future use. Licklider's model (see Figure 1) suggested that these works not just be housed and accessed; they should rather be synthesized and refined through artificial intelligence systems to provide users with a connection to the accumulated knowledge of human expertise. It was not sufficient to just provide data; in Licklider's conceptualization, the digital library would curate and contextualize information actively to suit the individual needs of the user. Although even the most modern computer technology falls short of Licklider's vision, Schatz (1997) noted that Licklider's

work laid the foundation for digital repositories and forms the basis for contemporary institutional and online search engines.

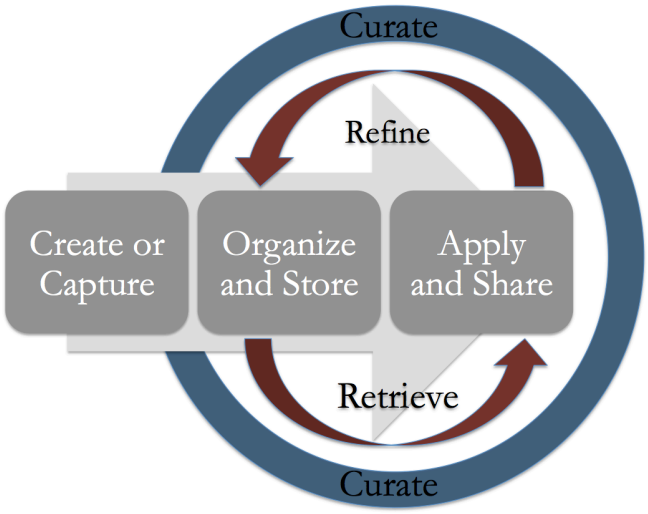


Figure 1. Conceptual model of Licklider's (1965) digital library.

Learning Objects

Learning objects are the foundation of educational repositories. This section will examine the early conceptions of learning objects, review definitions of learning objects, and examine four essential traits of learning objects: metadata, reusability, granularity, and interoperability.

Conception

The term learning object is commonly attributed to a Lego metaphor offered by Wayne Hodgins in 1994 (Ritzhaupt, 2010; Wiley, 2000). Hodgins' initial metaphor describes learning objects as small pieces of content connected by standards that can be combined together in a multitude of ways to facilitate learning (Hodgins, 2002). Because Legos are easily assembled with other pieces, this representation emphasizes the concept of *reusability* (Wiley, 2000). Hodgins (2002) later envisions a building

material analogy. A vast majority of construction materials are pre-built using standard dimensions and features, and modern architecture and construction simply finds a way to assemble these object into usable structures. The building material metaphor emphasizes the concept of *modularity*. To advance the concept even further, Mejias (2003), Norman (2004), and Wiley (2007) suggest a molecular metaphor for learning objects. This metaphor proposes that small pieces of content may be attracted to and be more likely to bond with certain content more than others. The molecular representation emphasizes that *context* is critical to the utilization of learning objects.

Definition

While there are many definitions of learning objects (Wiley, 2007), this manuscript emphasizes three definitions based on reusability, modularity, and appropriate context. The Institute of Electrical and Electronic Engineer's Learning Technology Standards Committee (Institute of Electrical and Electronics Engineers, 2005) defines a learning object as a digital or non-digital entity that can be used, reused, or referenced during learning (reusability). The Wisconsin Online Resources Center (2014) describes learning objects as learning materials that are flexible and adaptable to any place of learning (modularity). Cisco Systems (1999) proposes that learning objects are a collection of content, practice, and assessment items that are combined to meet learning objectives (context).

Metadata

Metadata is structured information that defines a learning object and enables management systems or users to quickly locate items, catalogue them, import or export them, or assign their use (National Information Standards Organization, 2004). Learning object metadata are simply data about data. Learning objects are tagged with

metadata upon creation and can acquire additional metadata through use. Metadata can be objective or subjective. Objective metadata describe content attributes such as authors, ownership, size, the number of item views, and grade level, and can be created by the author or automatically by repository software. Subjective metadata, however, typically refers to the application attributes (e.g. intervention or extension) of the learning object, and can be generated by authors or by users when they offer feedback (Hodgins, 2002). This feedback not only provides authors with useful advice for creating future content, it can provide potential users additional context for use.

Reusability and Granularity

Two critical factors regarding learning object use and reuse are economy and quality (Sampson & Zervas, 2011). An item is used when utilized in its intended context, and an item is reused when it is utilized in a different context (Polsani, 2003; Wiley, 2013). For example, a PowerPoint presentation showing the bridges of Portland, Oregon intended to meet fifth grade engineering design targets can be used by fifth grade teachers teaching similar content and reused by tenth grade teachers discussing the history of Portland. Creating high quality learning materials constitutes a high cost in human and financial resources, but Ochoa and Duval (2009) found that only 20% of learning objects are reused. Teachers generally craft learning objects for their own use, often without any intention of sharing with peers. Individual authoring is repeated multiple times for the same learning objective. Learning object use and reuse represent cost savings to districts by reducing the amount of time teachers spend creating materials that may see a single use or limited reuse. In addition, learning objects that see consistent use have more opportunity for user feedback, which can lead to higher quality assets (Sampson & Zervas, 2011). Thus, learning objects that attain a high level

of use and reuse can represent good economical value and pedagogical potential (Campbell, 2003).

Granularity indicates the size of the digital material that makes up a learning object (Wiley, 2013). Imagine beach gravel consisting of highly granular sand-like particles and rock-like low granular pieces. Granularity is related to reusability, as smaller objects (e.g., prompts, images, graphs) are more likely to be combined than larger objects (e.g., lesson plans, units, assessments) (Thompson & Yonekura, 2005). Unfortunately, this correlation implies that the learning objects with the highest pedagogical value may have the least likelihood of use. Wiley (2013) furthers this paradox: "It turns out that reusability and pedagogical effectiveness are completely orthogonal to each other…unless the end user is permitted to edit the learning object" (para. 3). In fact, the reuse of any learning object may depend upon the ability of the end user to adapt the material to their individual needs (Zimmermann, Meyer, Rensing, & Steinmetz, 2007).

Interoperability

In 1996, The Learning Technology Standards Committee (LTSC) of the Institute of Electrical and Electronics Engineers (IEEE) developed instructional technology standards that enable institutions to connect learning objects between repositories (Wiley, 2007). The two main interoperability standards are Sharable Content Object Reference Model (SCORM) and Common Cartridge (Gonzalez-Barbone & Anido-Rifon, 2010). The main objective of these standards is to ensure that content and functionality of learning objects is not lost when information is shared between repositories. For example, learning objects created and stored in the digital library CK-12.com work in Canvas, a widely used Learning Management System (LMS) via the Learning Tools

Interoperability (LTI) specification (IMS Global, 2016). Moreover, interoperability standards assure that platforms can access learning objects of various types and origins, deploy them in learning events such as courses or assessments, and potentially collect data from students. Finally, interoperability between learning objects within a repository (e.g., assembling prompts into an assessment, assembling lesson plans into a unit) provides educators multiple means to assemble and reuse a wide variety of item types.

Learning Object Repositories

Learning objects are stored in a form of digital library called a learning object repository (Wiley, 2000). A repository utilizes metadata to organize and describe learning objects in order to allow users to search for and use or reuse the content in instruction (Ullrich, Shen & Borau, 2013). In this section, I explain how organizations may benefit from repository use, describe factors that may affect repository growth and user participation, and define digital curation and its role in the learning object life cycle.

Organizational Benefits

Learning object repositories are platforms that store learning objects, enable users to easily access content, and provide a platform to increase collaboration among users (Namuth, Fritz, King, & Boren, 2005). The main benefits of building a repository are to facilitate the sharing of expertise within an organization and reduce the cost of duplicating instructional materials (OnCore Blueprint, 2008); i.e., a lesson produced once and used by 30 teachers is much more efficient than 30 teachers each producing one lesson. Brangier, Dinet, and Eilrich (2009) add that repositories also provide organizations with means to accredit content and affirm the institutional identity. Users

should not only have confidence that the materials housed on their repository are of high quality (accredit), they should also feel confident that the materials fit the identity and vision that the organization wants to promote (affirm).

Repository Growth and Participation

Repositories grow as authors contribute resources, and if only a small number of users create or use learning objects, the goal of building a repository may not be met (Xu, 2011). Institutions may allow any combination of curators, subscribers, and guests to contribute or use learning objects. The Orange Grove, NY Learns, and the Utah Education Network, for example, allow any registered guest to browse and author resources. Other repositories may limit access to resources and authorship privileges to members within the organization.

As visibility and knowledge of a repository increases with use, it is reasonable to assume that the amount of resources on it increases as well; yet there appear to be limitations on this growth. Ochoa (2011) states that the growth of most repositories is linear, not exponential, and that early contributors do not often turn into regular contributors. Users may feel initial excitement upon finding usable materials, and may author resources until the novelty wears off and a new activity competes for their time and attention. An additional limitation to participation was identified in one of the earliest studies of MERLOT, a learning object repository serving the California University system, Zemsky and Massy (2005) suggest that users were authoring resources for their own purposes yet were not consuming learning objects created by other users.

One repository, however, appears to have avoided authoring stagnation. OpenStax CNX (formerly Connexions), a project from Rice University, promotes

collaborative networking between authors and has seen exponential growth in learning materials (Ochoa, 2010). Expert contributors are encouraged to support and tutor sporadic or non-expert authors, and recognition and community status is reinforced. Thus, it appears that "the use of social engagement tools should be part of any new repository design" (Ochoa, 2011, p. 3).

Ochoa and Duval (2009) suggest there is no such thing as a typical repository user, and that contributors are best categorized in classes resembling socioeconomic levels. Though there may a large number of authors, the vast majority of them contribute few items and most resources are authored by a small number of active contributors (Ochoa & Duval, 2009). Nielsen (2006) describes this differentiation between "lurkers" and "contributors" (para. 4) in online communities with the 90-9-1 rule of participation inequality. Roughly 90% of users read but do not contribute, 9% of users contribute a little, and just 1% of users tally the most contributions.

Digital Curation and Life Cycles

Not yet achieving Bush and Vandevar's vision of an automated digital library, learning objects cannot yet organize or rate themselves. Assembly and evaluation can only take place when authors, users, or a third party curator actively interact with the learning object (Beagrie, 2006). Compared to learning objects that are passively housed on repositories, curation adds value to digital assets by providing users context for use and an implicit assurance of quality (Conyers & Dalton, 2008). Consider the educator who is searching for a science inquiry unit on the states of matter. There is little incentive to search an internal repository for limited unvetted resources with the entirety of the Web and a multitude of mixed-quality resources available. Even though the Web represents a minefield of hit-or-miss assets, the sheer quantity of material may

be more attractive to that educator than a few lessons created by colleagues. As a result, not only does the institution lose a potential value-adding return user, additional opportunities for collaboration and refinement are lost as well.

The term digital curation was coined in 2001 (Beagrie, 2006). Lord and Macdonald (2003) define digital curation as managing and endorsing assets to confirm they are suitable for discovery, use, and re-use. Pennock (2007) adds that curation increases the value of digital information for both current and future use. Curators must not only be aware of learning object features; they must also consider the pedagogical context into which it will best fit. Additionally, they should weigh the cost of archiving, preserving, and promoting a resource against the actual value of it. It is not in the best interests of the repository, nor the professional reputation of a curator, to endorse learning objects of questionable value or to sanction their use in the wrong educational environment.

Curators also manage the life cycles of digital learning objects. Hodgins (2002) states that learning objects require careful consideration at all stages of creation, use, reuse, and mortality. Changes in technology and content standards can render learning objects obsolete at any point in their life cycle (Pennock, 2007). In addition, authors may leave the organization, leaving assets *orphaned* without a person to contact regarding updating or editing content. The orphaned assets represent an investment of time and money from the past and should not be neglected. Thus, asset management and active curation (see Figure 2) at every stage is critical for maximizing pedagogic and economic value (Beagrie, 2006).

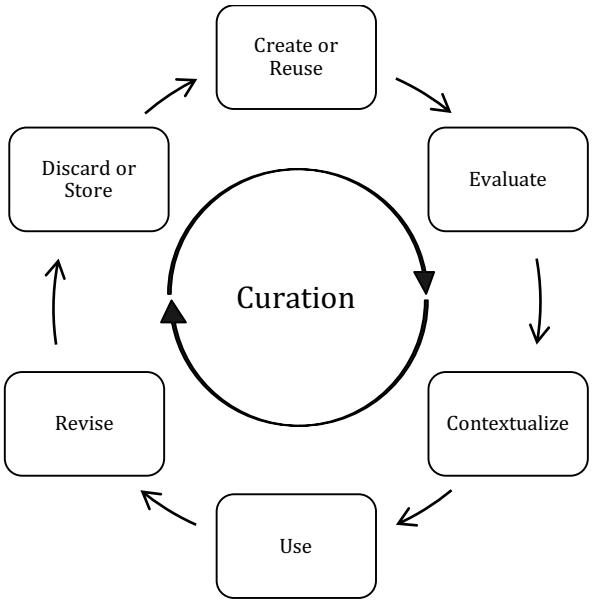


Figure 2. Learning Object Life Cycle. *Adapted from Beagrie, 2006*.

Methods for Evaluating Learning Objects and Websites

Several methods exist to evaluate the quality of learning objects. Kay and Knaack (2009) describe the use of summative assessments (e.g., surveys, interviews, frequency of use) that attempted to determine if users valued learning objects. Another instrument, the Learning Object Review Instrument (LORI), requires experts to review nine features of a learning object: content quality, learning goal alignment, feedback and adaptation capacity, motivation, presentation design, interaction usability, accessibility, reusability and standards compliance on a scale of 1-5 (Sanz-Rodriguez, Dodero, & Sanchez-Alonso, 2011). The MERLOT repository uses content area experts as well as end users to review learning objects on content quality, ease of use, and efficacy (Cechinel & Sánchez-Alonso, 2011). A common element to these evaluation systems is the reliance on a priori (expert) or a posteriori (user) opinion. Because many repositories lack the resources necessary to cover the continuous growth of materials,

Ochoa and Duval (2009) suggest sorting learning objects based on use, context, and other metadata that minimizes the need for human evaluation.

Prior to the widespread use of Google Analytics, organizations had several methods to evaluate website traffic and engagement (Fang, 2007). Paper-based surveys were limited to physical locations, and both paper- and web-based surveys were limited by subjectivity and human input. Web counters were able to count the number of visits to the site, but they did not provide any deeper understanding of users or the website (Dyrli, 2006). Web server log files provide a deeper understanding of user behavior, but the process of consolidating and evaluating raw log files is time consuming and difficult (Nicholas, Huntington, Jamali & Tenopir, 2006). Information can also be gathered from user profiles, but it is limited to users who sign up, give demographic data, and log on (Clark, Nicholas & Jamali, 2014).

Google Analytics, released in November, 2005, uses cookies, tags, and tracking codes to assess usage based on data received by the user (Google Analytics, 2014). Google Analytics provides organizations a simpler, more cost effective way to evaluate web traffic and engagement than previous methods (Clark et al., 2014). Web sites can track a wide variety of metrics through Google Analytics including the number of sessions (visits), the geographic location of users, and user engagement measures such as session duration and page views. Although Clark et al. (2014) caution that Google Analytics is built primarily to evaluate e-commerce, careful consideration of the metrics used enables Google Analytics to be applied to evaluate educational sites where teachers and students are the consumers and learning objects are the product.

TeacherSource Learning Object Repository

Beaverton Oregon school district (BSD) created TeacherSource, an electronic portal that is intended to "increase teaching information and encourage collaboration with other teachers" (BSD, 2012b, p.3). The repository went online in the fall of 2010 and was born out of an effort to provide teachers "high-quality instructional materials, an ability to collaborate with their colleagues, and a place to manage and organize instructional materials" (BSD, 2011, p.6). TeacherSource has been supported exclusively with BSD general funds and manages several types of learning objects, known as assets (either instructional or support), on a Microsoft SharePoint platform. Instructional assets include units, lesson plans, assessments, and prompts. Support assets included videos and support links (web links). All content has been authored by Beaverton teachers or attributed to an outside source.

The Beaverton School District has invested nearly $2 million in TeacherSource since 2010 (T. Frimoth, personal communication, September 19, 2014). Weekly usage data provided by the annual staff survey suggest that the repository may not be meeting its full potential as an institutional repository (BSD, 2012b). The school district established weekly usage goals at the beginning of 2012, culminating with at least 80% of teachers using the repository at least weekly by 2014-2015 (BSD, 2012b). Figure 3 shows the difference between the establish goals and the percentage of teachers reporting weekly use of the repository. Reported weekly use did not meet goals in the 2011-2012 and 2012-2013 school years, and a trend line of projected use for 2013-2014 and 2015-2016 falls significantly below established goals (BSD 2012a, BSD 2013). Beaverton School District ceased inquiry into TeacherSource use after the 2012-13 staff survey.

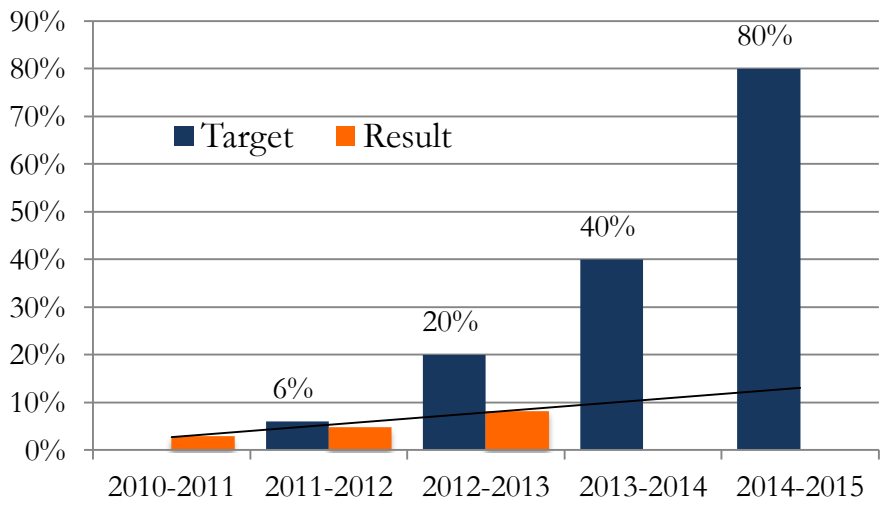


Figure 3. Percentage of teachers reporting at least weekly use of TeacherSource.

There are several factors that have brought TeacherSource into district policy discussions. First, Beaverton is transitioning from paper-based to digital resources. This Digital Conversion has four main components: staff development, wireless networking and connectivity, a Learning Management System, and school and classroom technology needs (BSD, 2014). Although TeacherSource does not affect wireless connectivity or classroom computer purchases, and the merging of TeacherSource assets with a LMS has yet to be conceived, the Digital Conversion section of the Superintendent's Bond Recommendation states that TeacherSource will be "…highly leveraged in providing resources and support for teachers" (BSD, 2014, p. 5). This document may help define the role of TeacherSource as it relates to the Digital Conversion Plan.

Additionally, Oregon House Bill 3233 (Network for Quality Teaching and Learning) allocated $5 million for Common Core implementation and a best practices clearinghouse. Representatives from school districts around the state were invited to the Oregon Department of Education (ODE, 2013, November) to discuss this clearinghouse. A portion of that money is dedicated to building a digital library. TeacherSource was not

only referenced as an example of a digital repository that would be able to meet the needs of the bill, department of education representatives have since contacted Beaverton School District to discuss a possible partnership with the state clearinghouse.

Beaverton school district has also been in discussions with neighboring school districts regarding the licensing of the TeacherSource platform (T. Frimoth, personal communication, September 19, 2014). These negotiations could potentially involve tens of thousands of dollars per year in revenue to Beaverton as well as provide additional opportunities for teacher training through inter-district sharing of courses and staff development personnel. In order to be able to initiate potential financial discussions with other organizations, Beaverton should be confident that repository policy as well as the design and interface meet the needs of current users. The district also needs a clear set of parameters by which to evaluate teacher participation as reflected by changes in policy regarding the repository. The first partnership with another district will likely serve as the basis for future consortium development with other districts in the state.

Finally, there is the issue of staffing. Since the beginning, Beaverton School District has staffed TeacherSource with one full-time employee. The TeacherSource project manager, a teacher on special assignment (TOSA), is solely responsible for all aspects of repository design, maintenance, promotion, and budget items. Beginning in the 2014-15 school year, TeacherSource added two half-time positions. As a result, TeacherSource is no longer exclusively passively curated. That is, while the majority of content is still user-generated and curated, now there are personnel that are able to edit, promote, contextualize, and vet assets. Future staffing plans may include the funding of additional full- or part-time curators.

Learning Objects and Standards

TeacherSource assembles learning objects (assets) based on learning targets. These learning targets are part of the Standards Based Learning System (SBLS) created by Beaverton School District. The SBLS Math and English Language Arts standards are based on the Common Core State Standards (CCSS) adopted by the Oregon State Board of Education in 2010 (ODE, 2010). Authors must assign at least one learning target to an instructional asset before publishing. This connection to a standard not only helps affirms an asset's connection to district instructional policy, it provides a means for users to search for materials based on standards. Support assets can be tagged by general area (e.g. Student tools, Games, Inspirational), subject area (e.g. math, literacy, science, technology), and grade level.

Reusability, Granularity, and Interoperability

TeacherSource has several ways to edit or reuse assets. Prompts and assessments can be created from other assets through a feature called *create similar*. This feature creates a new learning object with the exact same images, content metadata, standards, and text as the original. Users can edit the content of the asset to meet their own needs and can even correct errors or inaccuracies in the original without contacting the original author. Editing existing learning objects can save authors time as well as ease some of the potential anxiety of the authoring process.

Assembling existing assets of varying granularity is another way to reuse them (see Figure 4). Prompts have a high level of granularity and can be used independently or be assembled with or within other assets. Lesson plans and assessments can be created as stand-alone objects or be created from or paired with existing assets. Units,

assets with the lowest granularity, consist of multiple lesson plans and may include assessments and prompts.

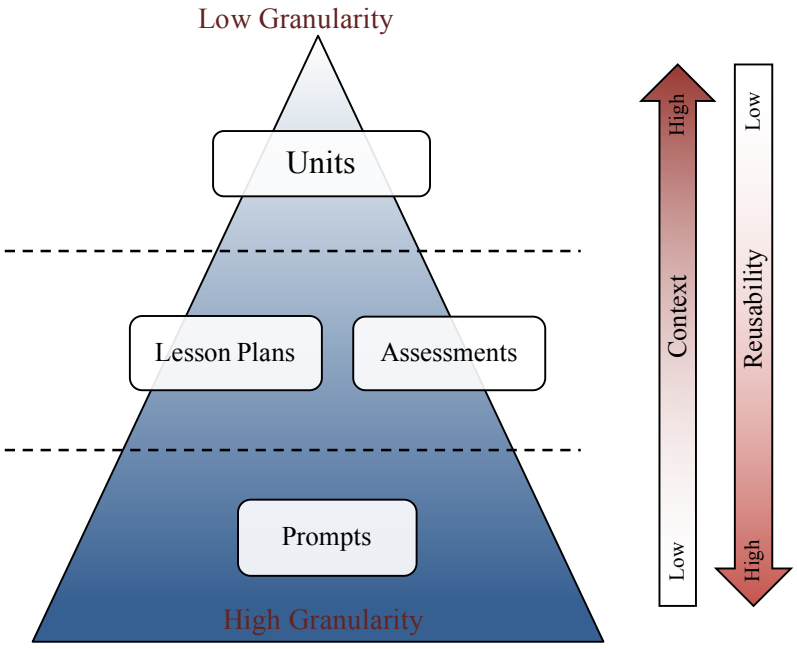


Figure 4. TeacherSource Asset Hierarchy.

Asset Evaluation: Metadata and Social Interaction

TeacherSource assets contain both objective and subjective metadata. Objective metadata such as learning targets, authors, date of publishing, length of session, and item type are created when an item is initially published. Because authors are often unwilling to put extra effort into creating metadata (Duval & Hodgins, 2003), the authoring template automates much of this process within TeacherSource. The number of views, the dates of the last edit, and information regarding the use of the asset in assessments or units are additional objective metadata that accumulate through use.

Social interactions are a key design feature of TeacherSource. Users can *Like*, *Favorite,* or *Share* assets. Liking simply marks an asset with a thumbs-up symbol,

similar to many social media sites. Favoriting allows users to place an asset into a folder that can be organized into categories (e.g., math, science, SIOP, differentiation) for quicker recovery at a later time. Sharing generates an email that links an asset to targeted users. Each of these features notify the author when activated and are tallied in a visible area on the asset thumbnail (see Figure 5). Not only do these social features provide the original author immediate feedback that one of their assets has been viewed and appreciated, it alerts other potential users that this item has undergone some peer review.

Figure 5. TeacherSource user-generated social asset metadata.

Chapter II

METHODOLOGY

This study examines five years of site traffic, user engagement, user-generated asset metadata, and authoring as a means to evaluate the TeacherSource repository and policies that support it (see Table 1). These metrics will assess a) site traffic and engagement, b) assets, and c) authoring to answer these questions:

1. How has repository traffic changed?
2. How engaged are users?
3. What is the state of repository assets?
4. How much social interaction is taking place?
5. What factors contribute to the authoring of assets?

Table 1: *Evaluation Categories, Measured Variable, and Data Sources*

Evaluation Categories	Variables	Data Sources: Google Analytics	Data Sources: Metadata Scan	Data Sources: Author Survey
Traffic and Engagement	Traffic:			
	• Number of Sessions	X		
	• One Day Users	X		
	• In/Out of District Access	X		
	• Sessions/Days of the Week	X		
	• Acquisition	X		
	Engagement:			
	• Pages per Session	X		
	• Session Duration	X		
	• Bounce Rate	X		
Assets	• Number		X	
	• Year of Creation		X	
	• Views		X	
	Social Interaction			
	• Likes		X	
	• Favorites		X	
	• Shares		X	
Authoring	• Author Participation		X	
	• Authoring Factors			X

Setting, Participants, Metrics, and Procedures

Beaverton School District is located in suburban Beaverton and Portland, Oregon. Beaverton is the third largest school district in Oregon with just over 40,000 students enrolled in 33 elementary, 19 options program, 8 middle schools, five option schools, five high schools, and two charter schools. The district employs 2,302 teachers and other certified staff, 1,667 classified personnel, 92 school administrators, and 30 district administrators. The 2014-2015 general fund-operating budget was $392,488,987. Student demographics are extremely diverse, with 94 different primary languages spoken in students' homes. Students of color account for 49.2% (State of Oregon 35.3%) of the student population. Students with Hispanic/Latino backgrounds account for the largest percentage of minority students (24%), followed by Asian American (13%). Beaverton's four-year cohort graduation rate for the class of 2013 is 77.2% (State of Oregon 68.7%), while 38.7% of students qualify for free and reduced lunch (State of Oregon 54%). The dropout rate for 2013-14 was 2.7% (State of Oregon 3.9%).

Time normalization

This analysis uses both longitudinal and cross sectional data. Google Analytics examines data from 2010-11 through 2014-15. Asset analytics, Author data, and Author survey data are date specific and noted in each section.

Google Analytics: traffic and engagement

Google Analytics provides TeacherSource Traffic and Engagement quantitative data. Google Analytics is a free service that generates detailed analytics (see Appendix A) for websites by sending a tracking tag that signals when a page has been displayed (Google Analytics, 2014). Google Analytic data is password protected. To assess how the

repository use has changed over time, I have been granted access to the TeacherSource Google Analytic website by the TeacherSource project manager.

TeacherSource has Google Analytic data on site metrics dating back to September 9, 2010. To establish a historical perspective on current metrics and establish baseline data, I examined traffic and engagement data from September 9, 2010 to July 31, 2011 and then from August 1tst to September 31 for each of the following years stopping at July 31, 2015. August 1st is a natural start to an academic year in Beaverton as most administrators start back after July 31.

Traffic data measures how much, from where, when, and how TeacherSource is visited. I examined the number of sessions, one day users, internal/external (either in-district or out-of-district) access, site acquisition (direct, referral, organic), and sessions by days of the week. The number of sessions is reported and the internal/external access was calculated with a simple ratio (e.g., 5,234/812). The percent change in both measures between reporting periods were also calculated. Mean one day users was calculated by totaling the number of one day users for the year and dividing the sum by the numbers of days in the year (2011-12 was a leap year). The sessions by days of the week was measured for each calendar year and in total. Acquisition types measured the number of sessions by direct, referral, and organic referrals. Direct acquisitions result from users typing in the exact web address or from setting that site as their homepage, which loads upon browser startup. Referral acquisitions result from a link on outside pages (e.g., email, website, or PDF document) that directs to the site. Organic search acquisitions result from search engine referrals.

Engagement measures include the average number of pages viewed per session, the average duration of each session, and the bounce rate (clicking out of the website

upon arrival). Because both average pages per session and average session duration may be heavily influenced by maximum and minimum values, I disaggregated these metrics using Google Analytics tables for each reporting period (see Appendix B). To gain a better understanding in changes of average Pageviews, I divided the data by range of page depth (e.g., 1, 2, 3 pages), the number of sessions at each page depth, and the total number of Pageviews at each page depth range. For average session duration, I divided the data by the default Google Analytics time ranges (e.g., 0-10 seconds, 11-30 seconds, 31-60 seconds), the number of sessions at each time range, and the number of Pageviews generated by each time range. This disaggregation provides greater detail into user behavior, and an examination of the tail ends of the data set and median values can potentially explain changes in mean values. For example, average pages per session may remain stable despite an increase in the bounce rate due to a small number of user sessions that accumulate a high number of page views.

Assets: total, views, and social interaction

Assets, views, and social interactions accumulate daily, I collected all asset data on September 25, 2015. The number of assets at this time was 8,225. I counted both the instructional (Units, Lesson Plans, Assessments, and Prompts) and support (support links and videos) assets. I divided asset views into ranges of 0-24, 25-49, 50-74, 75-99, and greater than 100 and then counted the number of assets within each category. Because of the high number of assets with less than 25 views, I further disaggregated the 0-24 group into categories of 0, 1-6, 7-12, 13-18, and 19-24.

For social interactions, I counted the total number of assets with interactions by type (Like, Favorite, and Share) as well as the total number of each interaction type

across all assets. I calculated the mean number of social interactions per asset by dividing the total number of social interactions by 8,225 assets.

Author report and survey

As assets are created, SharePoint collects metadata regarding the asset type and the author based on the original author's profile. I requested an author report on instructional assets (Units, Assessments, Lesson Plans, and Prompts) from the site vendor, AXIAN, on May 5th, 2015. This report provided information on the type and number of assets each user has authored. To estimate author participation, I grouped authors into light (1-5 assets), medium (6-20) assets, and heavy (21 or more assets) author groups and calculated a percentage of teachers within each authoring category. Because authoring has occurred continuously since 2010, I approximated the number of certified teachers within this time at 2,200 (see Appendix D).

I surveyed Beaverton School District teachers on their use of TeacherSource using Google forms (see Appendix C) and sent the invitation to all certified staff (N=2267). Certified staff members include all licensed teachers, school nurses, special education specialists, and school psychologists. I offered five $5 Starbucks gift cards and five $5 Amazon gift cards as randomly chosen incentives. I sent the initial survey invitation on May 4th, 2015 and a second invitation on May 8th. I closed the survey to responses on May 12th.

The survey gathered demographic data on sex, years of teaching experience, years in current position, and school level (elementary, middle school, high school, or other). A skip logic question created two groups: non-participants and participants. Non-participants reported they had never visited TeacherSource and the survey ended. Participants continued with the survey reporting how often they visit TeacherSource and

whether or not they had every published or used the site to find instructional resources. Additional four point Likert-Scale score items questioned participants to the degree they agreed or disagreed on the usefulness of TeacherSource, whether authoring can improve instructional practice or facilitate collaboration, and if the school district provided opportunities to author materials. Finally, the survey asked participants to select any social interaction (like, favorite, share, or comment) they had engaged in. I divided respondents into authors and non-authors for a regression analysis. A regression analysis is used, as there are more than one independent predictor variables that may determine an outcome.

Chapter III

RESULTS

This section details the outcomes of each research question. Results from Google Analytics, Asset metadata, the Author report, and the Author survey are displayed in tables or figures and key data are highlighted.

Research Question One – Repository Traffic

Repository traffic (sessions, mean one day users, acquisition) is displayed in Table 2. Sessions increased from an initial total of 9,685 in 2010-2011 to 180,591 sessions in 2014-2015 with increases of 129%, 199%, 64%, and 66% in each respective year. Mean one day users increased from 20.27 in 2010-2011 to 349.1 in 2014-2015 with increases of 114%, 200%, 71%, and 57% respectively. Internal access was much higher with a range of 64.31-76.25% compared to external access with a range of 23.75-35.69%. The last three years of data show a trend toward less external access.

Table 2: *Traffic. Number of Sessions and Internal/External Access*

Reporting Period	Number of Sessions	Mean One Day Users	Internal/External Access
2010-2011	9,685	20.27	69.61% / 30.38%
2011-2012	22,155	43.45	64.31% / 35.69%
2012-2013	66,263	130.51	73.40% / 26.60%
2013-2014	108,928	222.78	74.48% / 25.52%
2014-2015	180,591	349.1	76.25% / 23.75%

Figure 6 displays sessions by days of the week. The comparative number of sessions for each day has remained stable with sessions peaking on Tuesday, fewer sessions each day after, and the fewest sessions on Saturday. Tuesday has the highest total number of sessions (n=80,659) while Saturday has the fewest (n=11,330).

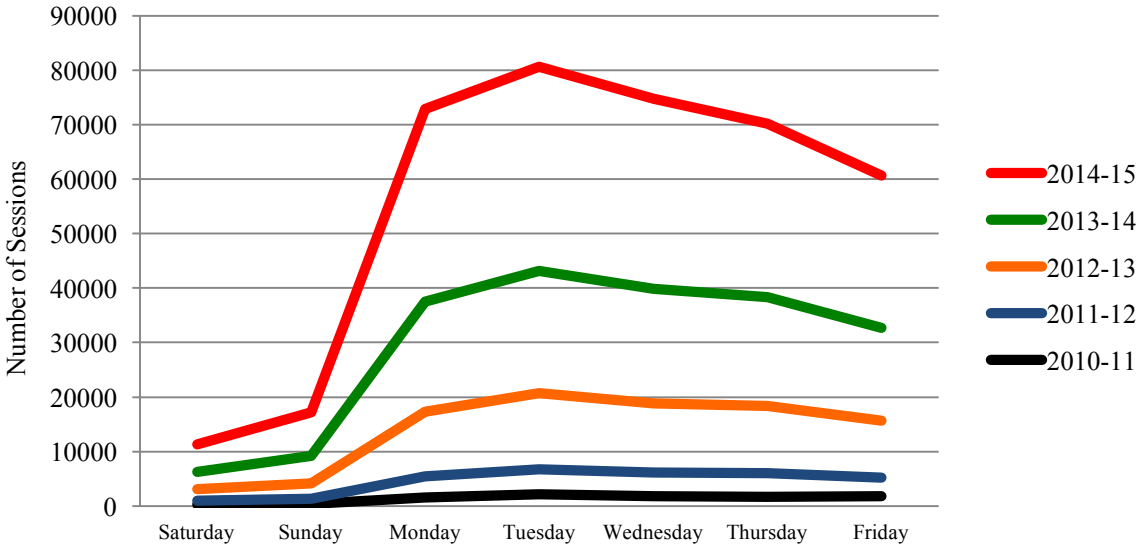


Figure 6: Sessions by Days of the Week by Academic Year.

The number of sessions by acquisition type (Direct, Referral, or Organic) as well as the percent of each type is shown in Table 3. In 2010-11, 63% of acquisitions were direct referrals. Beginning in 2011-12, referral acquisitions became the majority acquisition type, with 52% and peaking at 57% in 2013-2014. Organic referrals continue to be a minor acquisition source, with less than 3% every year.

Table 3: *Traffic. Acquisition by Type, Direct, Referral, Organic*

Reporting Period	Direct	Referral	Organic	Percent (D/R/O)
2010-2011	6057	3623	5	63/37/0
2011-2012	10,015	11,552	588	45/52/3
2012-2013	29,226	35,852	1,185	44/54/2
2013-2014	45,252	62,042	1,634	42/57/1
2014-2015	80,246	96,615	3,730	44/54/2

Research Question Two – User Engagement

User engagement measures are displayed in Table 4 (for Engagement histograms, see Appendix B). The percent change between years is noted in parenthesis. Engagement measures are steadily decreasing each reporting period. Average pages per session has gone from a maximum of 15.53 in 2010-11 to a minimum of 3.59 in 2014-15. Starting in 2010-11 through 2014-15, 62%, 78%, 89%, 92%, and 94% (respectively) of all sessions were 10 pages or less. Sessions with one Pageview increased each year as well. From 14% in 2010-11, single Pageview sessions rose to 28%, 44%, 43%, and 52% of all sessions in respective years (see Appendix B).

Average session duration has gone from a maximum of 14:48 in 2010-11 to a minimum of 4:33 in 2014-15. The bounce rate has increased from a minimum of 13.69% in 2010-11 to a maximum of 51.58% in 2014-15, with only 2013-14 (-2%) outlying the trend. A disaggregated view of mean Pageviews by session duration is displayed in Table 5. Mean Pageviews per session for each session duration category have been decreasing since 2010-11, with only increases in the 0-10 and 11-30 second session durations for 2013-14.

Table 4: *Engagement. Pages Per Session, Session Duration, Bounce Rate*

Reporting Period	Average Pages Per Session	Average Session Duration	Bounce Rate
2010-2011	15.53	14:48	13.69%
2011-2012 (% Change)	8.51 (-45%)	10:01 (-32%)	27.55% (+101%)
2012-2013 (% Change)	4.88 (-43%)	5:37 (-44%)	44.28% (+61%)
2013-2014 (% Change)	4.3 (-12%)	4:52 (-13%)	43.30% (-2%)
2014-2015 (% Change)	3.59 (-16.5%)	4:33 (-7%)	51.58% (+19%)

Table 5: *Disaggregated Mean Pageviews per Session by Session Duration 2010-15*

	Mean Pageviews per Session				
Session Duration	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
0 - 10 seconds	1.21	1.12	1.07	1.12	1.07
11 - 30 seconds	3.02	2.77	2.70	2.72	2.59
31 - 60 seconds	3.94	3.71	3.41	3.34	3.19
61 - 180 seconds	6.10	5.65	4.92	4.68	4.45
181 - 600 seconds	10.85	9.26	7.77	7.10	6.45
601 - 1800 seconds	19.84	13.78	10.09	8.94	7.50
1801+ seconds	53.01	35.36	28.92	29.58	24.18

Research Question Three – What is the State of Repository Assets?

Table 6 shows the total number of assets by type. The most common assets are lesson plans (45%), followed by prompts, (30%), and videos (12%).

Table 6: *Number of Assets by Asset Type*

	Asset Type						
	Total	Units	Lesson Plans	Assessments	Prompts	Support Links	Videos
Number of Assets	8225	274	3681	171	2438	670	992

Table 7 shows the number of assets in each view category and Table 8 shows a disaggregated view of the 0-24 views category. Out of 8225 assets, 1298 (15.8%) have 25 or more views. There are 216 (2.6%) assets in the repository that have 0 views, 882 (10.7%) assets with 1 view, 834 (10.1%) assets with 2 views, and 803 (9.8%) assets with 3 views. Assets with 4, 5, and 6 views number 553 (6.7%), 455 (5.5%), and 388 (4.7%) respectively. Assets with 6 or fewer views make up 50.2% (n=4131) of all assets.

Table 7: *Assets by Number of Views*

	Number of Views				
	0-24	25-49	50-74	75-99	>100
Number of Assets	6927	822	278	103	95

Table 8: *Disaggregated Number of Assets by Number of Views 0-24*

	Number of Views				
	0	1-6	7-12	13-18	19-24
Number of Assets	216	3915	1512	1009	457

Research Question Four – How much Social Interaction is taking place?

Table 9 shows the number of number of assets with social activity, the total number of each social interaction, and the mean social interaction type per asset. Out of 5,532 interactions on 3,539 assets, users have created more Favorites (n=3516) than Likes (n=1888) or Shares (n=128). The percent of assets with at least one Like is 15.3% (n= 1,261), at least one Favorites is 26.5% (n= 2182), and at least one Share is 1.2% (n=96). Mean interactions per asset for Liking, Favoriting, and Sharing are .23, .43, and .02 respectively.

Table 9: *Asset Social Interactions*

	Likes	Favorites	Shares
Assets with Social Interaction	1261	2182	96
Total number of Social Interactions-All Assets	1888	3516	128
Mean Social Interactions per Asset	.23	.43	.02

Table 10 shows a disaggregated view of the number of assets with social interactions. Assets with one social interaction (n=2477) account for 70% of the total interactions. Multiple interactions occurred on 371 (Likes), 529 (Favorites), and 20 (Shares) assets respectively.

Table 10: *Number of Assets with of Likes, Shares, Favorites*

Social Interaction	Number of Assets With Social Interactions										
	0	1	2	3	4	5	6	7	8	9	10+
Likes	6964	890	225	90	31	12	5	4	2	0	2
Favorites	6043	1511	374	147	69	38	21	11	1	3	7
Shares	8129	76	10	9	0	1	0	0	0	0	0

Research Question Five – Authoring

The author report showed 554 authors creating 7109 instructional assets between January 6, 2010 and May 17, 2015. Table 11 shows a disaggregation of authors by the number of items authored. During this time, the majority of teachers (approximately 80%) had not authored any items, while 15% authored between 1 and 5 assets, 3% authored between 6 and 20 assets, and 2% authored 21 or more. The light, medium, and heavy author groups averaged 1.79, 10.8 and 93.57 assets per author, respectively.

Table 11: *Authors by Authoring Category*

	Non Author	Light Author	Medium Author	Heavy Author
Authored Assets	0	1 to 5	6-20	21+
Number of Teachers	2200*	409	88	58
Percent	80%	15%	3%	2%
Total Assets	0	732	950	5427

*Approximate number of teachers (2011-2015)

Table 12 shows the total number of assets authored each year and the percent increase between years. Year four produced (2013-2014) nearly as many assets (1,412) as the first three years combined (1,477). Year five (2014-2015) produced more assets than the first four years (2010-2011 through 2013-2014) combined, with 62% of all assets authored in 2014-2015.

Table 12: *Assets Produced Each Year*

Reporting Period	% Increase	Total
2010-2011		371
2011-2012	41%	524
2012-2013	11%	582
2013-2014	143%	1412
2014-2015	231%	4672

The author survey returned 815 responses (36%) out of 2267 invitations (see Appendix D). Respondents were majority (78.4%) female (176 male, 639 female), had teaching experience ranging from 1 year to 44 years (mean=14.22, mode=15, SD=8.60), and current position experience ranging from 1 to 35 years (mean=6.16, mode=1, SD=6.11). School level numbers showed 426 elementary staff (52.27%), followed by 193 high school staff (23.68%), 143 middle school staff (17.55%), and 53 other staff (6.50%). A majority (83.19%) reported confidence with technology (see Figure 7).

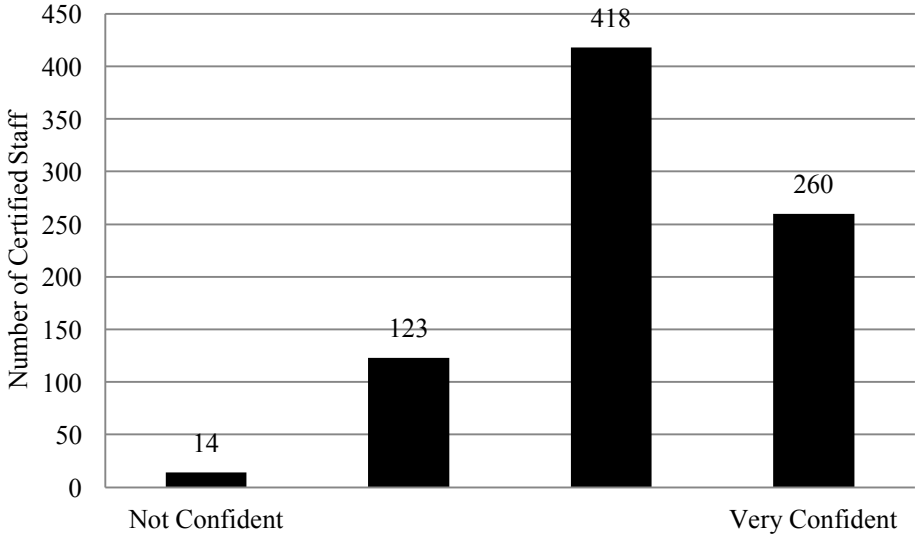


Figure 7: Certified staff confidence with technology.

A skip logic question distributed respondents into non-participant (n=19) and participant (n=796) groups. Participants reported they had visited TeacherSource. Participant groups were further divided into non-contributor (n=581) and contributor (n=215) groups depending on whether they reported authoring any assets. Participant groups reported 66.83% (n=532) using TeacherSource to find instructional materials. Nearly half the participants (n=383) reported visiting TeacherSource a few times a year, 293 reported visiting a few times a month, 91 weekly, and 29 reported daily visits. A small majority (43% agree, 10% strongly agree) thought that TeacherSource was useful (40% disagree, 7% strongly disagree). A majority of participants (see Table 13) agreed that authoring can help instructional practices (71%), that authoring can facilitate teacher collaboration (75%), that TeacherSource was useful to teachers (53%), and that the district provides opportunities to author (61%).

Table 13: *Survey Authoring Responses*

Question	Strongly Disagree	Disagree	Agree	Strongly Agree
Authoring resources can help instructional practices	43 (5%)	188 (24%)	433 (55%)	127 (16%)
Authoring can facilitate teacher collaboration	37 (5%)	164 (21%)	425 (54%)	163 (21%)
The district provides opportunities to author	77 (10%)	229 (30%)	323 (41%)	154 (20%)

A regression analysis determined factors that affect authoring. The predictor variables for instructional practice, technology confidence, and years teaching were significant. The results (see table 14) include the coefficients in the logit scale, their standard error, the coefficients as odds ratios $EXP(\beta)$, and 95% confidence intervals for the odds ratios.

Table 14: *Logistic Regression Results*

	Logit	SE	OR	95% CI	
Intercept	-3.4047849	0.547915090	0.03321396	0.01109389	0.0952566
Technology Confidence	0.3185547	0.121244293	1.37513890	1.08738864	1.7499427
Instructional Practice	0.2421008	0.112096299	1.27392256	1.02480345	1.5911685
Years Teaching	0.0397523	0.009674692	1.04055300	1.02106833	1.0605964

To address the lack of interpretability of the logit scale, odds ratios are used. For technology confidence, every unit step increases the odds of authoring at least one asset compared to not authoring by 1.38, which is statistically significant, indicated by the 95% CI not crossing 1. For instructional practice, every unit step increases the odds of

authoring at least one asset over not authoring by 1.27, which is statistically significant, indicated by the 95% CI not crossing 1. For years of teaching, every additional year step increases the odds of authoring at least one asset over not authoring by 1.04, which is also statistically significant with the 95% CI not crossing 1. Because the years teaching ranges between 1 and 44 years, a five-year interval may be a more meaningful coefficient. Thus, for every five years of teaching experience, the odds of authoring at least one asset over not authoring increases by 3.36.

These coefficients are displayed as predicted probabilities in Figure 8. Along the X-axis is years of teaching experience and along the Y-axis is the probability of authoring an asset. The blue dashed line indicates teachers who are a 4 on confidence with technology and instructional practice. The red dashed line indicates teachers who have high technology confidence, but are low on instructional practice. The blue solid line represents teachers with high instructional practice, but low confidence with technology. Finally, the solid red line represents teachers low in both technology confidence and instructional practice.

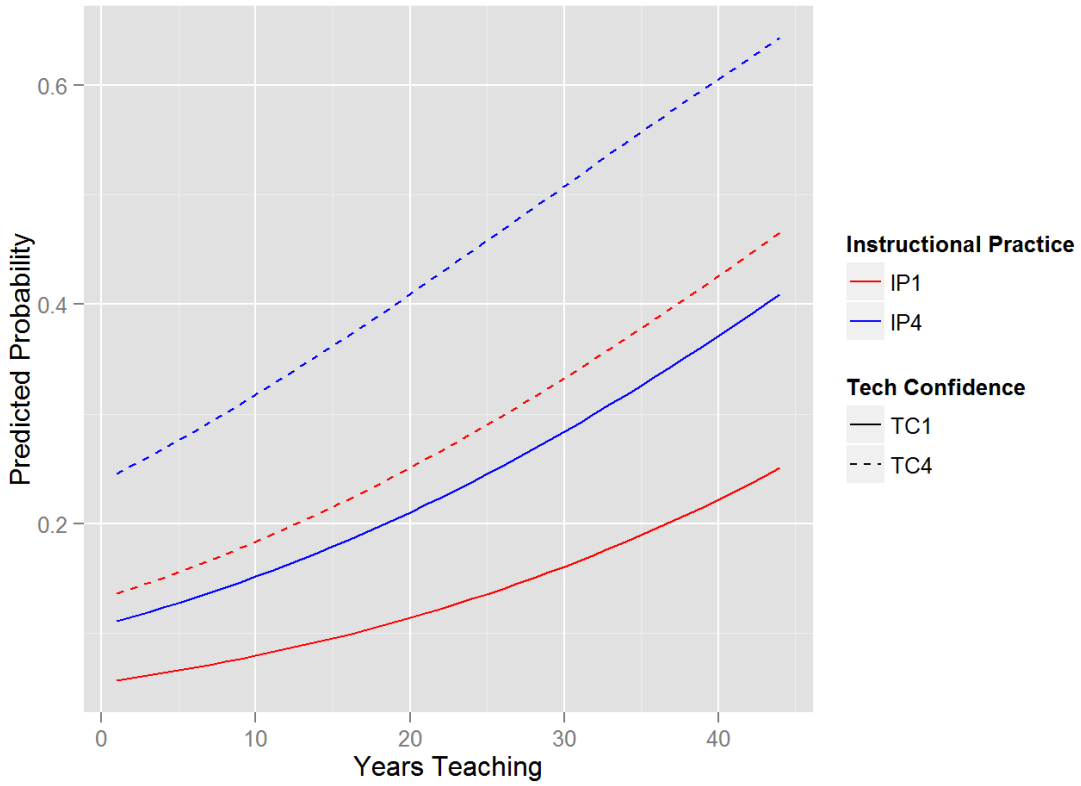


Figure 8. Predicted Probability

The predicted probability table permits comparisons between teachers on the likelihood of authoring. For example, a teacher with 20 years of teaching experience with a high confidence in technology and a belief that authoring can improve instructional practices would have slightly greater than twice the chance of authoring over a teacher with 10 years of experience, a high degree of technical confidence, but a low belief on the impact on instructional practice. A teacher with 30 years of experience, but low technology confidence and instructional practice impact, would have about half the probability of authoring compared to a teacher with only 10 years of experience, but with high technology confidence and instructional impact belief.

CHAPTER IV

DISCUSSION AND CONCLUSION

This section reviews the research results and outlines study limitations. Additional discussion of future research and implications are followed by the study conclusion.

Summary of Findings

This research examined site traffic and engagement data of a digital library, asset growth, views, and social interaction, as well as factors that influence authoring. TeacherSource has had large increases in sessions and assets over five years, but user engagement measures have declined. Social interactions associated with learning materials were low, but asset views show mixed potential of use and reuse. Asset growth increased each year culminating with a very large increase in year five. Finally, several factors were identified that predict authoring.

Traffic increases may be influenced by several factors. One possible explanation for the increase in traffic could be attributed to the increased importance of TeacherSource as a document repository, communication tool, and professional development portal. In this regard, TeacherSource has met the OnCore Blueprint (2008) objectives of sharing expertise and reducing duplication costs. The Community section, initially an ad hoc document host, has become the principal repository for rubrics, curriculum guides, and shared Google files. The majority of documents here have been added by district subject area specialists and carry district branding and language, which is intended to add a degree of accreditation and affirm their use (Brangier et al., 2009). Additionally, a number of schools have created Community

pages as a supplemental communication tool and document host. Finally, all professional development activity is now managed within TeacherSource.

Several factors may affect engagement measures (Ochoa, 2011). When users find resources faster through design familiarity and/or navigation improvements, average Pages per Session and Session Duration should decline. Both measures have declined every year. Indeed, the average number of pages viewed within specified time spans (e.g. 11-30 seconds) has declined each year in each time span with only two minor increases in 2013-2014. Furthermore, the percent of sessions lasting 10 pages or less has increased each year, from 62% 2010-11 to 94% of all sessions in 2014-15. Alternatively, this decrease in engagement data could be the result of users not finding what they need and leaving or not trusting the implicit assurance of quality (Conyers & Dalton, 2008). The consistent increases in sessions across all Pageview groups make the latter scenario less likely; as users would not likely return if initial visits were unfruitful.

The bounce rate trend is not so clear. After doubling in year two and increasing by more than half in year three, it decreased a bit in year four, followed by a large increase in year five. This odd pattern may be influenced by an unofficial policy change. Beaverton School District's public webpage is set as the default homepage on all staff computers. That is, when a teacher starts up any of the included web browsers on their district computer, the first page that loads is the Beaverton website. Stemming from a push from the Teaching and Learning department, some teachers have changed their default homepage to TeacherSource. Thus, no matter the webpage a teacher intended to visit upon browser startup, a session is logged. As a result, sessions and bounce rates may increase, while the pages per visit and the average visit duration may decrease. However, the percentage of direct referral acquisitions has remained steady (between 42

and 45%) for the last four years, so homepage behavior may not be the only contributing factor to the changes in bounce rate. It is likely in the best interests of the district to retain visitors to the site, and ensuring that content and information meets the needs of users may minimize bounce rate. Active resource management and curation, an essential part of digital information (Pennock, 2007), is essential to providing users with what they need when they need it, ultimately improving engagement measures.

Consistent with Ochoa and Duval (2009), TeacherSource assets show a mixed potential of use and reuse. Nearly half of all assets accrued six or fewer views, and just over 200 assets had zero views. There is some promise, however, as 2,764 assets have been viewed 25 times or more, and nearly 200 have been viewed more than 75 times. Although there is no current way to determine how, when, and by whom a resource was used, assets with multiple views provide value-adding potential compared with assets that are never shared. Mirroring Zemsky and Massy's (2005) review of MERLOT, it appears that many users are authoring assets for their own purposes and not using resources created by others.

These numbers also may reflect both dimensions noted by Sampson and Zervas, (2011) – Economy and quality – or adaptability as noted by Zimmermann, et al. (2007). A higher number of views may imply that content has a higher value, but this research did not attempt to determine asset quality. Assets may also receive different numbers of views depending on subject area need. For example, there may be an increased use of high school social studies materials compared to high science due to the scope of adopted curriculum. Similarly, elementary math resources may not be utilized due to the fact that the current math curriculum already has more lessons than there are days of school. This research did not attempt to determine asset activity by subject area or

grade level. Continued disaggregation of subject and grade data could help improve development priorities.

The original intentions of the social interaction tools were to facilitate communication between teachers, encourage future authoring, and provide other users some indication of asset quality. These tools are not widely used. Although hundreds of assets have multiple social interactions, the vast majority have generated none. Adding to Favorites was the most commonly used social interaction tool, which suggests that teachers were more likely to save learning materials for later than to provide Kudos to peers. Future designs could include a more robust rating tool, such as the LORI (Sanz-Rodriguez et al., 2011) or even the five-star scale shared by Amazon.com and Canvas LMS.

TeacherSource asset growth outperformed typical repositories (Ochoa, 2011). The number of assets created in 2013-14 nearly matched the first three years combined, and the number of assets created in 2014-15 nearly doubled the combined output of the first four years. Assets swelled from just under 3,000 through the first four years to nearly 8,000 in year five. This growth is well beyond the linear growth that Ochoa (2011) finds in most repositories, and more closely resembles the exponential growth of the socially engaged OpenStax repository (Ochoa, 2010). While current social engagement tools may not be contributing to a critical mass of social interaction and drive asset creation, a total of 42 paid work sessions beginning in 2013-14 may be fostering the social environment associated with increased asset growth. These informal face-to-face meetings provide opportunities to share ideas, meet teachers in other buildings, and collaborate on projects that typical professional meetings do not.

The number of users who have contributed content is consistent with other online environments (Nielson, 2006). Authors did form groups that resemble Ochoa's and Duval's (2009) socioeconomic classes. Approximately 80% of users have not authored any content, 15% of users have contributed less than ten percent of the assets, while 5% have created more than eighty percent of the total. This compares favorably to Nielsen's (2006) 90-9-1 rule of user participation, with a slightly higher participation rate.

Several factors predict the likelihood of authoring content. These include confidence with technology, belief of a positive impact of authoring on instructional practices, and years of teaching experience. The reported confidence using technology was a major predictor of authoring seems reasonable, as digital authoring often requires finding, interacting with, and uploading files. Future training will no doubt continue to focus on increasing teacher experience and comfort with technology, and newer teachers will likely bring more technology savvy with them, so computer aptitude may become less of a barrier than it currently is. Similarly, if organizations reinforce and provide evidence that contributing content adds value to instructional practices, then teachers may be more likely to contribute material. Finally, while years of teaching experience is not an actionable factor, districts might consider using this variable to identify staff for targeted professional development and/or the creation of hetero- or homogeneous groups.

On one hand, a limited number of authors can simplify the process of asset creation and curation. Because learning objects require attention at all stages of their life cycle (Hodgins, 2002), fewer authors may provide less variability of item formats and quality, a reduced need for training authors, and a streamlined system for dealing

with orphaned assets. On the other, many teachers already author their own content on a regular basis without the intent of cooperation, refinement, or peer review. This practice in not as iterative or collaborative as authoring content in a common digital environment and may be less likely to result in high quality learning materials. Encouraging more teachers to participate in authoring and then providing active curation can add value to assets (Conyers & Dalton, 2008) by providing additional assurances of quality as well as contexts for use.

Study Limitations

Quantitative analyses provide consistent and reliable data, but may not provide enough context to fully understand all factors of a complex environment. As Clark et al. (2014) cautioned, Google Analytics is intended to evaluate e-commerce, which allows for additional objective measures such as advertising and sales data. While traffic and engagement measures show trends, they do not provide explanations for them. Additionally, this research did not analyze what pages were visited or by whom.

The central task of a digital library is to house resources for classroom use, and analyzing asset views and social metadata does not take into consideration what behavior the user engaged in during or after the interaction with the asset. There is no indication as to how, when, or even if materials were used with students. Ultimately, this information may only be accessible via voluntary contributors, as some teachers may not want to broadcast what resources they use. Additionally, I did not analyze assets by topic, grade, or author. Assets may have gathered more views or social interactions than others based on content area need, not quality. Finally, this study made no attempt to determine asset quality or link them with author variables.

The author survey queried 2,267 certified staff using the "All district certified" email directory. Certified positions that are not instructional in nature, such as school nurses, psychologists, and human resources staff received the survey yet may not have the need to visit or participate in the repository. Teachers on leave (e.g. family or medical) may not have received the survey invitation within the survey window, which could have limited participation.

TeacherSource is a unique resource, which potentially limits the generalizability of this study. For one, it has not been created with open-access in mind. That is, there is no means for outside users to register and then author or consume resources. This closed environment allows users to share potentially sensitive information (e.g. class pictures, videos of lessons, student work samples) much more simply. Many repositories in the United States that cater to K-12 teachers are open-access and simply require user registration to author and/or use resources. Another unique aspect of TeacherSource is that a single district, not a consortium, state agency, or a for-profit company has created it. Beaverton is also a relatively large district located in an affluent suburb of metropolitan Portland, Oregon, and has been able to dedicate the resources to build and operate a repository even during an economic downturn.

Future Research and Implications

Three areas are proposed for future work. As the next phases of repository features and policies are development, changes in traffic, user engagement, social interactions, and asset development should be monitored. For example, would a simplification of the authoring process increase participation? Would the integration of a more powerful social interaction tool, such as Yammer or Slack, affect asset views and social interaction?

Second, a deeper examination of variables will enable a more concise means to pin conjectures to variables. For example, certain characteristics of assets might lead to increased metadata activity. An individual or group of authors might be generating a high number of social interactions or views compared to others in that subject area or grade level. Those teachers might include specific features that encourage greater use or reuse of assets. Likewise, important subject areas might be generating no metadata at all, which could indicate a lack of quality materials, teacher participation, or the impact of another curriculum. Finally, certain pages may be driving traffic to the repository. Google Analytics does provide a means to examine user paths and count page visits, and an examination of granular navigation data could provide more meaningful data on traffic and engagement measures.

Third, the district should explore more robust methods to evaluate instructional resource quality as well as factors that may influence it. Authors currently contribute through three paths: as part of their regular practice, hourly pay in work sessions, and stipend work groups; and there may be reasons to expand or contract those paths or even limit participation based on teacher qualification or asset quality. While an asset evaluation tool (e.g. LORI) may be difficult to implement, an evaluative tool such as Amazon's five-star rating system may provide users additional assurance that resources meet quality standards. The rating system may also work as a mechanism to evaluate any policies that lead to the creation of that asset.

The implications of this research can guide future development and policies. Because the number of single Pageview sessions is increasing each year, it is critical that the landing page users see upon arrival contain the most essential material. Although a user may intend to visit another site when starting a browser session, relevant

information may still be transmitted during that brief interaction. TeacherSource is more and more being relied upon as a communication alternative to email. Currently the dashboard provides some messaging and navigation shortcuts to commonly used district sites, and continued development of this tool might better capture the attention of users passing through. Moreover, events and policies that generate increased social interaction should be encouraged. Although this research did not directly tie paid work sessions to asset creation, the potential effects of social interaction on exponential asset growth in both OpenStax and TeacherSource are considerable.

Conclusion

Schools are increasingly relying on digital environments to store, deliver, and collect learning materials. This transition, however, is not without challenges. Educators may be reluctant to embrace new technology or change existing practice, limits in technology infrastructure can interfere with usability, and digital conversions can be expensive. Beaverton School District started this process more than six years ago with the creation of the TeacherSource learning object repository.

In those six years, much has happened with digital learning. Google Apps For Education (GAFE) has emerged as a powerful tool for both students and educators, websites such as Kahn Academy and CK-12 provide resources for teachers as well as individualized instruction to students, and comprehensive Learning Management Systems now span university through K-12. Moreover, Open Educational Resources (OER), such as Eureka Math are starting to disrupt traditional for-profit publishing companies. Not surprisingly, some of the biggest players in the digital economy have also started to move into digital education, as Facebook and Amazon are developing digital libraries and instructional tools that use adaptive programming to provide

students what they need when they need it. We may indeed be finally starting toward Licklider's (1965) "Library of the Future."

The curation of digital resources, regardless of platform, will increasingly be an essential part of 21st century education. With the rapid expansion and evolution of e-learning platforms, it is important to consider that the practices of curation will likely change as well. Curation will not just focus on individual learning objects within repositories, it will expand to include finding the best digital content and practices on a much larger scale. Curation of digital content and platforms might even start to replace the traditional publisher-based curriculum from which many school districts base their instructional programs. This rapid transition may clash with entrenched policies such as school board curriculum cycles and mandated adoption processes, and curators may overlap and eventually replace traditional curriculum specialists. Districts that are intent on implementing digital curricula would be wise to quickly address these potential points of contention.

The next phases of TeacherSource policy and development will be heavily influenced by the adoption of the Canvas LMS for 2016-2017. Canvas has some feature overlap with digital libraries, and some current functions handled by TeacherSource will be ceded to the LMS. A key consideration is the number of environments that teachers can access voluntarily compared to the number that are mandatory to maintain. Teachers already have multiple systems (e.g. student information system, data warehouse, email, testing portal) that are necessary for their job, and another mandate (hard or soft) may not be well received. Furthermore, it is unlikely that the adopted LMS will be able to fully replace TeacherSource in the near future, particularly with regards to the Community page and professional development, so district leadership will need to

balance the merits of both in order to smooth the transition. There is also the issue of asset interoperability, as thousands of TeacherSource assets will need to be integrated with or imported into the LMS. This interface has yet to be fashioned, but an LTI specification as well as using GAFE should be considered.

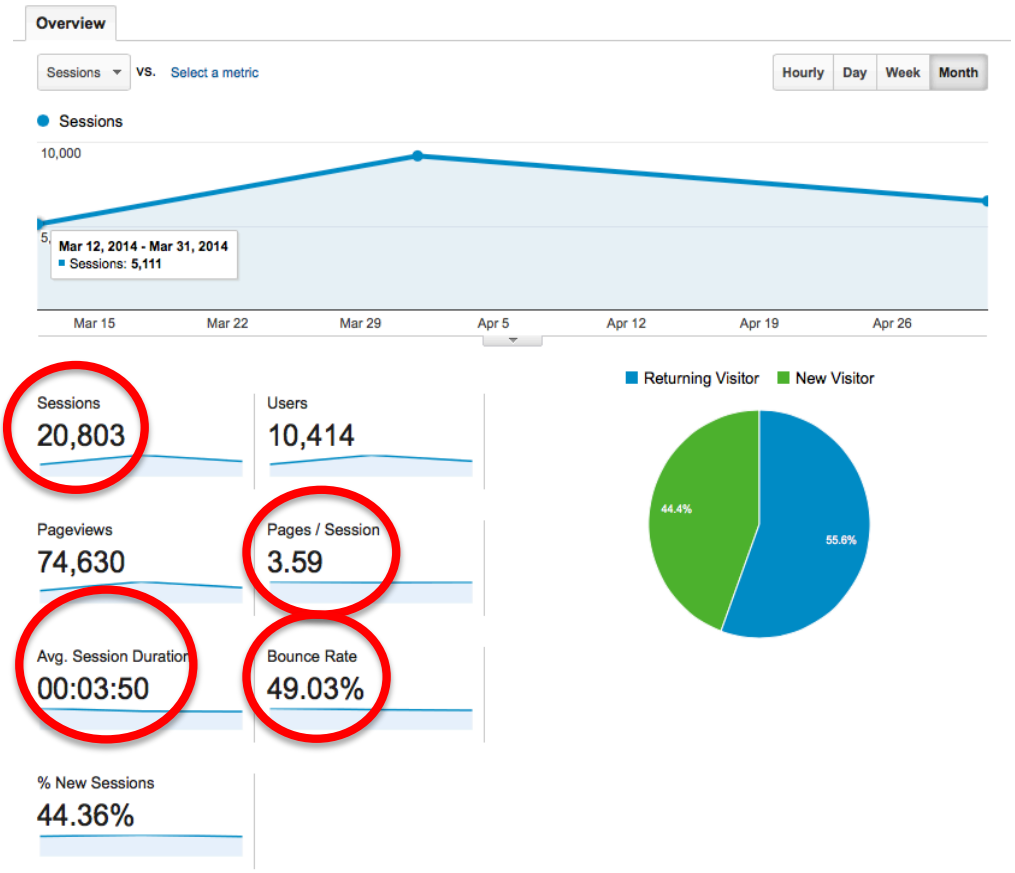
Digital tools seldom persist. The practice and culture that develop around them, however, can endure through multiple technological iterations. In this regard, TeacherSource has not radically changed the way teachers find content, plan, and collaborate. The notion of TeacherSource as a comprehensive teacher tool has not been fulfilled. It has, nevertheless, successfully laid the foundation for Beaverton's transition to more modern instructional practices, and it continues to expand in uses that were not part of the original design. Ultimately then, the TeacherSource experiment has been successful. For roughly the cost of three or four teachers a year, the platform has provided Beaverton School District with a place to innovate and start envisioning future instructional shifts.

This research can inform district policy as it relates to future repository development, communication, professional development priorities, and LMS integration. Despite no mandates from the district, TeacherSource authoring has steadily increased each year and the repository is approaching more universal use. Authoring, traffic and engagement data can be used as similar benchmarks during the implementation of the LMS and authoring data can inform teacher participation strategy in future learning object environments.

APPENDICIES

Appendix A

Google Analytic Report (Sample)



Appendix B

Disaggregated Engagement Data (Google Analytics)

2010-2011

Session Duration	Sessions	Pageviews
0-10 seconds	1,604	1,921
11-30 seconds	610	1,837
31-60 seconds	684	2,695
61-180 seconds	1,491	9,097
181-600 seconds	1,853	20,121
601-1800 seconds	2,045	40,619
1801+ seconds	1,398	74,153

Page Depth	Sessions	Pageviews
1	1,326	1,326
2	683	1,366
3	1,062	3,186
4	639	2,556
5	560	2,800
6	476	2,856
7	397	2,779
8	351	2,808
9	305	2,745
10	238	2,380
11	253	2,783
12	230	2,760
13	201	2,613
14	197	2,758
15	188	2,820
16	171	2,736
17	137	2,329
18	120	2,160
19	108	2,052
20+	2,043	102,630

2011-2012

Session Duration	Sessions	Pageviews
0-10 seconds	6,861	7,712
11-30 seconds	1,549	4,291
31-60 seconds	1,610	5,963
61-180 seconds	3,117	17,619
181-600 seconds	3,725	34,484
601-1800 seconds	3,188	43,952
1801+ seconds	2,105	74,626

Page Depth	Sessions	Pageviews
1	6,104	6,104
2	2,774	5,548
3	2,154	6,462
4	1,501	6,004
5	1,207	6,035
6	1,010	6,060
7	842	5,894
8	664	5,312
9	563	5,067
10	504	5,040
11	453	4,983
12	357	4,284
13	328	4,264
14	287	4,018
15	256	3,840
16	225	3,600
17	206	3,502
18	172	3,096
19	157	2,983
20+	2,391	96,551

2012-2013

Session Duration	Sessions	Pageviews
0-10 seconds	31,567	33,976
11-30 seconds	4,542	12,262
31-60 seconds	3,952	13,472
61-180 seconds	7,341	36,089
181-600 seconds	8,416	65,342
601-1800 seconds	7,435	75,013
1801+ seconds	3,010	87,128

Page Depth	Sessions	Pageviews
1	29,338	29,338
2	8,812	17,624
3	6,973	20,919
4	4,010	16,040
5	2,873	14,365
6	2,159	12,954
7	1,697	11,879
8	1,372	10,976
9	1,148	10,332
10	905	9,050
11	786	8,646
12	660	7,920
13	528	6,864
14	514	7,196
15	441	6,615
16	354	5,664
17	331	5,627
18	275	4,950
19	249	4,731
20+	2,838	111,592

2013-2014

Session Duration	Sessions	Pageviews
0-10 seconds	53,115	59,512
11-30 seconds	9,657	26,236
31-60 seconds	6,810	22,742
61-180 seconds	11,935	55,906
181-600 seconds	12,639	89,735
601-1800 seconds	10,765	96,263
1801+ seconds	4,007	118,269

Page Depth	Sessions	Pageviews
1	47,169	47,169
2	17,505	35,010
3	12,714	38,142
4	6,676	26,704
5	4,778	23,890
6	3,693	22,158
7	2,693	18,851
8	2,057	16,456
9	1,667	15,003
10	1,437	14,370
11	1,135	12,485
12	916	10,992
13	791	10,283
14	613	8,582
15	493	7,395
16	453	7,248
17	388	6,596
18	321	5,778
19	278	5,282
20+	3,151	136,269

2014-15

Session Duration	Sessions	Pageviews
0-10 seconds	99,604	106,668
11-30 seconds	11,626	30,098
31-60 seconds	9,626	30,737
61-180 seconds	17,591	78,230
181-600 seconds	18,485	119,192
601-1800 seconds	17,292	129,631
1801+ seconds	6,367	153,928

Page Depth	Sessions	Pageviews
<1	73	0
1	93,148	93,148
2	28,416	56,832
3	16,776	50,328
4	9,492	37,968
5	6,694	33,470
6	4,727	28,362
7	3,609	25,263
8	2,713	21,704
9	2,259	20,331
10	1,679	16,790
11	1,376	15,136
12	1,165	13,980
13	976	12,688
14	811	11,354
15	641	9,615
16	598	9,568
17	544	9,248
18	445	8,010
19	370	7,030
20+	4,079	167,659

Appendix C

Author Survey

This survey is part of a doctoral research study and will take no more than a minute or two of your time. There will be prizes awarded at random for participants.

I am a D.Ed candidate at the University of Oregon. The purpose of the research is to determine factors that affect staff use of TeacherSource. Your participation is completely voluntary. There is no penalty for not participating, and you may discontinue the survey at any time.

There is no risk to you personally or professionally. No personal information will be reported, and your responses will be kept confidential. Any identifiable information will be deleted as soon as the data analysis has been completed.

This research is designed to explore the influences on the creation of digital learning resources. Even if you have not authored any items on TeacherSource, your answers can provide useful information.

The results may help improve the usability and utility of TeacherSource, may help guide future professional development, and may provide a better user experience for all teachers in the district.

If you have questions before, during, or after the survey, please contact Steve Simpson. Questions regarding your rights as a research subject can be directed to the University of Oregon's Research Compliance Service. A copy of the consent form will be provided upon request. By clicking on the survey link, you are providing consent to participate in the survey.

Are you male or female?

- Male
- Female

What best describes your current position?

- Elementary
- Middle School
- High School
- Other

How many years have you been teaching?

Years (whole number)

How confident are you using technology?

	1	2	3	4	
Not Confident					Very Confident

How many years have you been in your current position?

Years (whole number)

Have you ever visited TeacherSource?

- Yes
- No

How often do you visit TeacherSource?

- A few times a year
- A few times a month
- Weekly
- Daily

TeacherSource is useful to teachers.

	1	2	3	4	
Strongly Disagree					Strongly Agree

Have you ever used TeacherSource to find instructional resources?

- Yes
- No

Have you ever published any content on TeacherSource?

- Yes
- No

Authoring instructional resources on TeacherSource can help improve instructional practices.

	1	2	3	4	
Strongly Disagree	○	○	○	○	Strongly Agree

Authoring instructional resources on TeacherSource can facilitate teacher collaboration.

	1	2	3	4	
Strongly Disagree	○	○	○	○	Strongly Agree

The district provides opportunities to author instructional materials on TeacherSource.

	1	2	3	4	
Strongly Disagree	○	○	○	○	Strongly Agree

Have you ever?
Check all that apply

- ☐ "Liked" a resource
- ☐ Added a resource to "favorites"
- ☐ "Shared" a resource
- ☐ Commented on a resource

Appendix D

Table 15: *Beaverton School District Certified Staff 2010-2015*

School Year	Certified Staff
2010-2011	*
2011-2012	2,307
2012-2013	2,019
2013-2014	2,134
2014-2015	2,330
Mean	2197.5

* Incomplete Data

Appendix E

History, Context, and Policies of a Learning Object Repository

Steve Simpson
University of Oregon
D.Ed Program 2016

1

Why?

TEACHERSOURCE

Use vs. Potential

Problem of Practice

Opportunity

2

Knowledge Gaps

Implementation

Participation

Authoring

3

Context & History

2009: Store, Consume, & Collaborate

Low Initial Use

No clear alternative

4

Study Purpose

History & Use

Authoring

Future

5

Conceptual Framework

Digital Libraries

Bush (1945): "As We May Think" Memex
-Intelligent Association

Licklider (1965): "Libraries of the Future" Metadata
-User Needs

6

Conceptual Framework

Learning Objects

Reusability, Modularity, Context

Hodgins (1994): Lego
Hodgins (2002): Building Material
Wiley (2007): Molecule

A resource or practice that can be used or modified within a learning context.

7

Conceptual Framework

Learning Object Repositories

Namuth et al. (2005): Content and Collaboration
Brangier et al. (2009): Accredit and Affirm

Ochoa & Duval (2009): 20% reuse
Ochoa (2011): Linear or Exponential growth, Social Engagement
Nielson (2006): 90-9-1 Rule

8

Conceptual Framework

Evaluation

Learning Objects

Kay & Knack (2009): Summative Assessments
Ochoa & Duval (2009): Use, context, and metadata

Websites

Google Analytics (2014): 2005, cookies, tags, tracking codes
Clark et al. (2014): Teachers/Learning Objects

9

Key Elements

Repository

Traffic and Engagement

Assets

Creation and Social Interaction

Authoring

Participation and Factors

10

1. How Has Repository Traffic Changed?

Methodology

Google Analytics

Sessions
One Day Users
In/Out of District Access
Sessions by Days of Week
Acquisition

11

2. How Engaged Are Users?

Methodology

Google Analytics

Pages Per Session
Session Duration
Bounce Rate

12

3. What Is the State of Repository Assets?

Methodology

Asset Metadata

Total Number
Views

13

4. How Much Social Interaction Is Taking Place?

Methodology

Asset Metadata

Likes
Favorites
Shares

14

5. What Factors Contribute to the Authoring of Assets?

Methodology

Author Survey

Demographic Data
Comfort with Technology
Impact on Instructional Practice
Collaboration

15

Findings

Traffic and Users

	Sessions	One Day Users
2010-2011	9,685	20.27
2011-2012	22,155	43.45
2012-2013	66,263	130.51
2013-2014	108,928	222.78
2014-2015	180,591	349.1

16

Findings

User Engagement

	Pages/Session	Session Duration	Bounce Rate
2010-2011	15.53	14:48	13.69%
2011-2012	8.51	10:01	27.55%
2012-2013	4.88	5:37	44.28%
2013-2014	4.3	4:52	43.30%
2014-2015	3.59	4:33	51.58%

17

Findings

Assets

Number of Views

	0-24	25-49	50-74	75-99	>100
Number of Assets	6927	822	278	103	95

	0	1-6	7-12	13-18	19-24
Number of Assets	216	3915	1512	1009	457

18

Findings

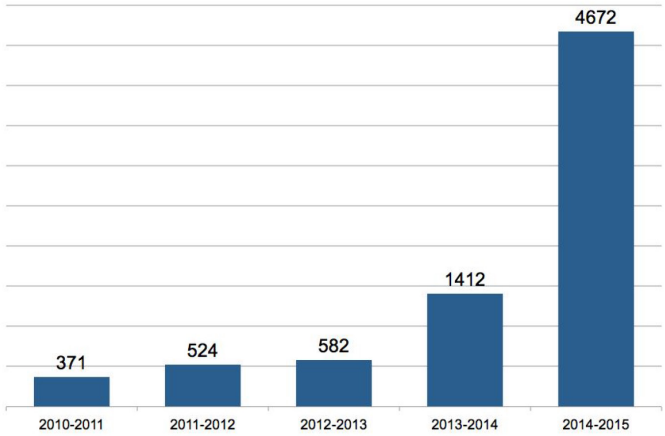
Social Interaction

	Likes	Favorites	Shares
Total Interactions	1888	3516	128
Mean per Asset	.23	.43	.02

19

Findings

Authoring: Assets Per Year



20

Findings

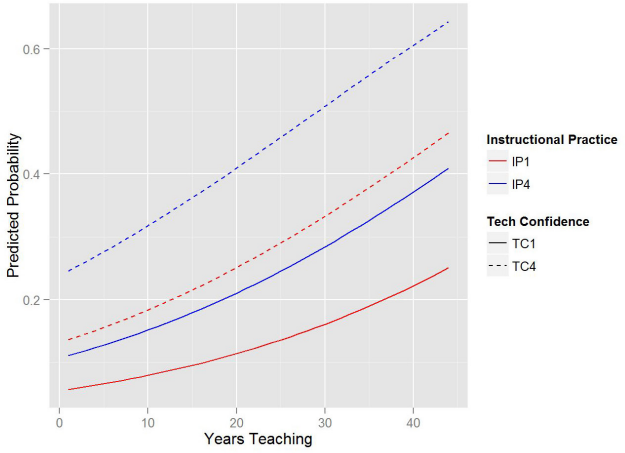
Authoring: Participation

	Non Author	Light Author	Medium Author	Heavy Author
Authored Assets	0	1 to 5	6-20	21+
Number of Teachers	2200*	409	88	58
Total Assets	0	732	950	5427
Percent	80%	15%	3%	2%
Mean Assets/Author	0	1.79	10.8	93.57

21

Findings

Authoring: Factors



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Conclusions

Large Increases in Traffic

Decreased Engagement

Mixed Asset Use

Limited Asset Social Interaction

Asset Growth + Social Interaction

Authoring

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Implications and Recommendations

Emergence of OER Resources and GAFE

Kahn, Amazon, Facebook

Digital Curation

Canvas LMS

TeacherSource Future

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Thank You

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