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Patterns of Learning Object Reuse in the Connexions Repository

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PATTERNS OF LEARNING OBJECT REUSE IN THE CONNEXIONS REPOSITORY

by

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ABSTRACT

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Since the term *learning object* was first published, there has been either an explicit or implicit expectation of reuse. There has also been a lot of speculation about why learning objects are, or are not, reused. This study quantitatively examined the actual amount and type of learning object use, to include reuse, modification, and translation, within a single open educational resource repository–Connexions. The results indicate that about a quarter of used objects are subsequently reused, modified, or translated. While these results are repository specific, they represent an important first step in providing an empirical evaluation of the frequency and some reasons for reuse, as well as establishing metrics and terminology for future studies.

(73 pages)

DEDICATION

Yia-Yia,

Thank you for instilling in me the importance of always following one's dreams and passions and of always being true to oneself.

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I would like to thank all my friends and family, both biological and academic, for all the inspiration, support, and reality checks provided over the years.

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S. M. Duncan

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CHAPTER I

INTRODUCTION

> The promise of learning objects is commonly described as that of “building it once and using it many times,” either within an institution or globally. (Goldsmith, 2007, ¶ 2)

> The cost of the average learning object is between $2,500 and $25,000… (Dunning, 2004, abstract)

> [If] A high quality and fully interactive piece of learning material could be produced for, perhaps, $1,000. If 1,000 institutions share this one item, the cost is $1 per institution. But if each of a thousand institutions produces a similar item, then each institution must pay $1,000, with a resulting total expenditure of $1,000,000. For one lesson. In one course. (Downes, 2001, ¶ 4)

Learning objects is a staple term to 21st century instructional designers and educational technologists. Wiley’s (2002) definition, “any digital resource that can be reused to support learning,” provides an intuitive sense of what a learning object is. As with many new technologies, instructional designers want to incorporate learning objects in their designs. The reasons range from flexibility, cost-effectiveness, and customizability (Smith, 2004) to the Sharable Content Object Reference Model (SCORM) -ilities: durability, portability, reuseability, interoperability, and accessibility (Ostyn, 2004). The key driving force behind many of these reasons is cost-effectiveness, and the cost-effectiveness of learning objects lies in their reusability.

Since the early 1990s, when Wayne Hodgins is credited with coining the term (Wiley, 2002), there have been attempts to standardize learning objects and their metadata in order to facilitate their reuse, there have been articles describing how to reuse learning objects, other articles questioning the potential reusability of learning objects, and articles deriding the possibility of sound instructional design with learning objects. One area of research that is lagging behind these others is an empirical evaluation of actual learning object reuse. Because the primary argument in favor of the use of learning objects is that their reuse makes them a cost-effective method of developing and deploying instruction, it is vital that we understand if and how reuse is occurring. Learning objects have now been in use for well over a decade, and perhaps we have obtained the critical mass to evaluate learning object reuse. If this reuse is not occurring and a critical mass of objects currently exists, then the foundation of the argument for the significant expense and pain taken to use learning objects disappears like a certain emperor's new clothes.

Learning Objects History

In the 1960s, researchers described how "curricular units can be made smaller and combined, like standardized Meccano [mechanical building set] parts, into a great variety of particular programs custom-made for each learner" (Gerard, 1969, as cited in Gibbons, Nelson, & Richards, 2002).

Merrill's component display theory (Churchill, 2007; Cramer, 2007; Heyer, 2006; Laverde, 2007; Minguillon, 2007), from 1980, is often referred to as a predecessor attempt to develop a learning object-like system. The core concepts underlying CDT were a two-dimensional learning objective classification system (content and performance) and two levels of presentation that would be most effective for a specific class of learning objective (Merrill, 1983). Component display theory eventually evolved into instructional transaction theory (ITT), and what had been the content dimension of the learning objective classification system became known as knowledge objects. Merrill based this theory on a database model (Merrill, 2000).

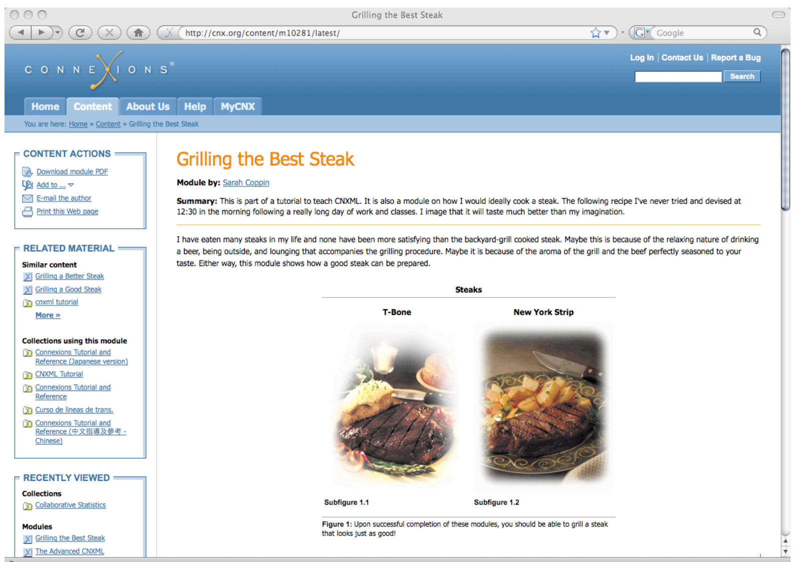
Wayne Hodgins credited the plug-and-play nature of his children's Lego building blocks as the inspiration for the term, *learning objects* (Hodgins, 2002). Whereas, Merrill's concept of a knowledge object is structured content without strategy or presentation (as strategy and presentation would be added by a computer algorithmically), the Lego concept of learning objects is much broader, less defined, and often views learning objects as self-contained, stand-alone, mix-and-match instructional components with strategy and presentation embedded directly in the resource.

In the same period as Hodgins and the educational technology community were contemplating the Lego/learning object possibilities, the computer science field was starting to embrace a programming paradigm known as object-oriented programming. Some advocates of learning objects envision them from this object-oriented perspective, which aligns with the vision of Merrill's knowledge objects, separating out content and presentation, or in the language of object-oriented programming, separating the attributes (i.e., characteristics of the content) from the methods (i.e., actions related to the content).

For sake of clarity, consider an example learning object of each type. A concrete example of a Lego-ish object that contains all of its content, strategy, and presentation is a *webpage* that has content about the Battle of the Bulge, uses a storytelling strategy to communicate its message, and uses specific fonts, screen layouts, and colors in its presentation. A concrete example of a Merrill-esque object that contains only content separated from strategy and presentation is an XML file containing country names and capitals. Note that the XML file contains neither strategy information about how to teach the countries and the capitals, nor images of the countries, other graphic representations of the countries, or any other instructions about how to present the information.

For the most part, objects from these two paradigms are not compatible. For example, a Lego-ish object often contains both the content and presentation precombined (see Figure 1a), and, therefore, could not be integrated into an object-oriented system (which expects to receive strategy-free and presentation-free content as an input). On the other side, an object-oriented object that contains only content, would not be useable in a system that expected the content and presentation combination of a Lego-ish object (have you ever seen an XML file in your web browser, such as Figure 1b, when you expected a normal webpage?).

1a.



1b.

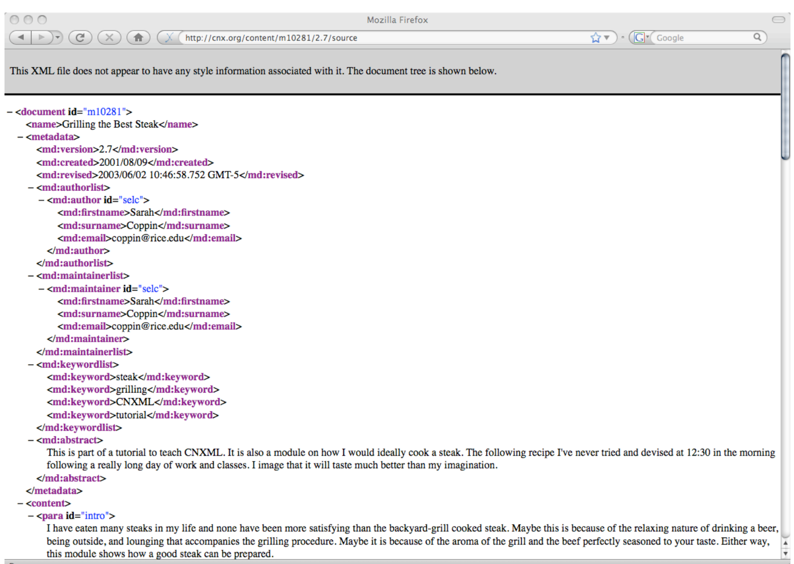


Figure 1. A single learning object with (a) the content and presentation precombined and (b) a presentation–free version of the content.

The Integral Concept of Reuse

One result of these competing views is the proliferation of definitions for the term *learning object*. While there is not a single accepted definition for "learning object," there is one concept that recurs consistently across all definitions of learning objects–their potential for reuse.

> Any digital resource that can be **reused** to support learning. (Wiley, 2002, p. 6)
>
> A digitized entity which can be used, **reused** or referenced during technology supported learning. (Rehak & Mason, 2003, p. 21)
>
> [D]igital, self-contained, **reusable** entity with a clear learning aim that contains at least three internal changing and editable components: content, instructional activities (learning activities), and context elements. As a complement, the learning object should have an external component of information which helps its identification, storage, and recovery: the metadata. (Laverde, 2007, ¶ 11)
>
> SCORM is a collection of standards and specifications adapted from multiple sources to provide a comprehensive suite of e-learning capabilities that enable interoperability, accessibility and **reusability** of Web-based learning content. (SCORM, 2004)
>
> Cisco Systems recognizes a need to move from creating and delivering large inflexible training courses, to database driven objects that can be **reused**, searched, and modified independent of their delivery media. This effort is called the Reusable Information Object Strategy. (Barritt, Lewis, & Wieseler, 1999, p. 1)

Not all definitions explicitly include reusability as a characteristic of learning objects, but in most of these cases, there is still an implicit expectation of reuse. For example, the Institute of Electrical and Electronics Engineers (IEEE) Learning Technology Standards Committee (LTSC) did not include reusability in their learning object definition, "Any entity, digital or non-digital, that may be used for learning, education or training", but they do include it implicitly and explicitly, in their Learning Object Metadata (LOM) standard's statement of purpose, "The purpose of this multi-part Standard is to facilitate search, evaluation, acquisition, and use of learning objects, for instance by learners or instructors or automated software processes. This multi-part

Standard also facilitates the sharing and exchange of learning objects, by enabling the development of catalogs and inventories while taking into account the diversity of cultural and lingual contexts in which the learning objects and their metadata are reused" (Learning Committee, 2003). Reusability is *clearly* a key part of all conceptualizations of learning objects, and is integral to their value proposition.

As with all innovations, there is a period of time when the innovation is diffused through potential communities of use (Rogers, 2003). This diffusion can lead to a large range of results–from being discarded to rapid assimilation–in communities of use never imagined by the innovators. Current research on diffusion of innovation focuses on innovation adopters. This study does not examine specific adopters, instead it focuses on use and reuses of the innovation without reviewing the characteristics of the adopters within a defined system. In this respect, it does not address where the whole field is in the diffusion adoption process, but it does provide some key point-in-time metrics for use in subsequent diffusion studies.

Purpose of the Study

Given the centrality of learning object reuse to the popular argument in favor of their use, and the lack of empirical work examining learning object reuse, the purpose of this study was to begin analyzing the actual rate and nature of reuse of learning objects. The primary research question of the study was, "*How much and what kind of learning object reuse is currently occurring?"* The basic statement of the study purpose and question will be elaborated as relevant literature and research methodology are described.

CHAPTER II

LITERATURE REVIEW

Included and Excluded Literature

In the literature search for this study, the original search string [(SU "learning objects" or KW "learning objects") and (TX reuse OR reusable OR reusing OR "re using")], in the Academic Search Premier, Psychology and Behavioral Sciences Collection, and PsychINFO databases, resulted in 43 records. However, a search removing the reusability related terms [SU "learning objects" or KW "learning objects"] in the same databases resulted in 101 records. With the prevalence of reusability as such an integral learning object concept, and interested in knowing why there was such a discrepancy between the two record sets, a review of the first five available resources that (a) had a focus on learning effectiveness (as opposed to more technical or deployment related foci) and (b) are not included in the literature review results was conducted. For each of these five articles a search for words related to reusability was performed. The following quotes from four of the queried pieces highlights the implicit reusability theme.

> Until now metadata have been used to ensure the interoperability and reusability of learning objects; now the use of metadata and meta-data schemes becomes an important aspect of learning itself. (Allert, Richter, & & Nejdl, 2004, p. 9)

> I assigned the students to read Cisco's (2001) Reusable learning object strategy. This seminal white paper outlines and provides guidelines for Cisco's strategy to transition from creating and delivering large inflexible training courses, to database-driven objects that can be reused, searched and modified independent of their delivery media. (Metros, 2005, p. 97)

> Learning objects (LOs), generally understood as digital learning resources shared and accessed through the Internet and reused in multiple learning contexts, have aroused enthusiasm in the field of educational technology. (Nurmi & Jaakkola, 2006, abstract)

> This sharing is possible through online repositories stocking large numbers of LOs that different user groups (teachers, instructional designers, learning material producers, learners etc.) can access and reuse in various instructional contexts according to their contemporary needs. (Nurmi & Jaakkola, 2006, p. 234)

> Much like containers of learning, which are independent, self-contained units of instructional content ready to be used and reused in diverse educational contexts (Polsani, 2003), learning objects may require or contribute to the acquisition of metacognitive skills. (Sanchez-Alonso & Vovides, 2007, p. 2,587)

The fifth article never explicitly mentioned reusability; however, the study's methodology reused existing learning objects (Ilomäki, Lakkala, & Paavola, 2006). The results of this quick query confirmed that even studies that were not focused on reusability acknowledged—either explicitly or implicitly, through study design—that one of the recurring expectations of learning objects is either actual reuse or the possibility of reuse.

Once the results were limited to peer-reviewed journal articles and editorials were removed the list dropped to 30 articles. Each article from this list was reviewed. Ultimately five additional articles were removed, one for being strictly a literature review and the rest due to a lack of details or relevance related to learning objects.

Review Categories

Before any study can successfully progress, the constructs being researched must be operationally defined. Sadly, the definitions, descriptions, and constructs of learning objects vary widely, even the term that researchers prefer for their concept of a learning object varies (e.g., some prefer "instructional object"). This disparity within the construct of learning objects not only makes research difficult, it makes the possibility of reuse difficult. For example, if researcher one defines learning objects as "any object that can be used in a learning context" while researcher two defines them as "any digital object that can be used in a single educational lesson"; researcher one might be able to reuse objects from researcher two, but objects that qualify under researcher one's definition, such as a rock for a geology lesson, or a large digital simulation like the Sims,™ would preclude their reuse for researcher two.

For the purpose of this study, the operational definition of *learning object* is anything identified as a learning object. This is clearly a broad, recursive definition. Its breadth specifically allows for the inclusion of any research literature tagged with learning object as a subject or keyword regardless of whether the author/s identified their materials as learning objects. Its recursive nature allows for the inclusion of any materials identified as learning objects by any other definition (e.g., if a rock or the Sims™ have been identified as a learning object by any definition, then, for the purposes of this study, they are a learning object).

In addition to a basic definition, there are at least two distinct perspectives that learning object designers can approach in the development of learning objects: separated layers ("Merrill-esque") or encapsulation ("Lego-ish"). In the proper environment, the separated layers or Merrill-esque approach allows for more reuse of the content, to include multiple presentations of the same data. Encapsulated or Lego-ish objects are often less complicated and expensive to create, but more difficult to modify. Each approach has pros and cons within the realm of reuse, but rarely can these two categories of learning objects be reused in a single system.

Moving beyond problems with the operational definitions and potential for reuse, the next question is what have researchers actually done in relation to reuse (as opposed to what they have theorized about reuse). Not to give away the ending, but of the 25 articles reviewed in depth—each of which was tagged with a reuse-related keyword—only five actually involved the reuse of learning objects, and in three of those the reuse was deliberately pre-planned, contrived, or occurred only on a very small scale. As learning objects is still a relatively young research area one would expect a relatively small base of published research, but the general unavailability of published research looking empirically at “real” reuse was nevertheless surprising.

Synonyms, Homonyms, and Paronyms—Oh My!

There is no single agreed-upon definition for the term *learning object*; many educational designers and researchers have alternate terms for similar constructs, often times designers and researchers have multiple levels or categories of learning objects, and even when a construct is agreed upon the interpretation of that construct can vary widely.

Among the selected articles, there were 21 different definitions given for *learning object*; this definition count did not include references to definitions that the authors referred to but did not use in reference to their own work. Nine articles use someone else’s definition (Green, Jones, Pearson, & Gkatzidou, 2006; Griffiths, Stubbs, & Watkins, 2007; Gunn, Woodgate, & O'Grady, 2005; Heyer, 2006; Krull, Mallinson, & Sewry, 2006; Reilly, Wolfe, & Smith, 2006; Ting, Zimolong, Schiffers, & Radermacher, 2006; Wang & Hsu, 2006; Weinreich & Tompkins, 2006), while the authors of 11 articles create their own definition (Koppi, Bogle, & Bogle, 2005; Kurubacak, 2007; Lam et al., 2004; Lee & Su, 2006; Liber, 2005; Lukasiak et al., 2005; Muzio, Heins, & Mundell, 2002; Phillips, Hawkins, Lunsford, & Sinclair-Pearson, 2004; Sjoer & Dopper, 2006; Tompsett, 2005; Weller, 2004), and five authors never explicitly provide the definition used in their study (Bing, Hosseini, Keck, & Kheng, 2006; McCormick & Li, 2006; Pegler, 2005; Poldoja, Leinonen, Valjataga, Ellonen, & Priha, 2006; Ting et al.). Only Polsani’s definition of a learning object as an “independent and self-standing unit of learning content” (Polsani, 2003) was used as the study definition in more than one study (Green et al.; Heyer). Different versions of definitions attributed to Wiley (2002) are used for three articles: “small, reusable chunks of instructional media” (Weinreich & Tompkins), “any digital resource that can be reused to support learning” (Reilly et al.), and “small, self-contained piece of knowledge content turned to the satisfaction of a well defined and specific learning goal” (Ting et al.).

While each of the articles reviewed is tagged with the keyword *learning object*, many authors prefer other terms. Among the alternative terms are: reusable learning object (RLO; Griffiths et al., 2007; Kurubacak, 2007; Phillips et al., 2004; Tompsett, 2005), reusable granules (Griffiths et al., 2007), e-materials (Wang & Hsu, 2006), complex digital objects (CDO; Reilly et al., 2006), learning resources (inclusive of assets and sharable content objects [SCOs]; Bing et al., 2006), pages (Green et al., 2006), atomic learning objects (ALO; Lee & Su, 2006), composite learning objects (CLOs; Lee & Su), digital item (DIs; this term was derived from the MPEG21 standard; Lukasiak et al., 2005), unit of study (UOS; Lukasiak et al.), guest learning objects (e.g., media derived from presentations given by guest speakers; Pegler, 2005), E-learning objects (ELOs; Muzio et al., 2002), and interactive ELOs (Muzio et al.).

The authors of several articles highlighted their distinctions among either hierarchies or categories of learning objects. The articles emphasizing hierarchical relationships between learning objects described the subcategories of learning objects as: learning and information objects (Heyer, 2006); assets and SCOs (Bing et al., 2006); ALOs and CLOs (Lee & Su, 2006); and DI and UOS (Lukasiak et al., 2005). In one of the three articles that included a categorical breakdown of LOs, some of the categories were hierarchical in nature; the categories are raw asset, learning asset, task or exercise, learning design with content (includes one or more objects within the previous three categories), and generic learning design (Koppi et al., 2005). One of the other two categorical systems simply indicates the expected lack of or presence of user interaction (Muzio et al., 2002). The final categorical breakdown has three main categories: instructional objects, individual activities, and companion activities. The companion activities category is further categorized into collaborative activities, technical activities, narrative objects, and assignments (Weller, 2004). Individual activities are defined as self-contained activities. Companion activities are activities linked to a database. Collaborative activities require collaboration with other students. Technical activities require interaction with external technologies, such as blogs, and may involve collaboration. Narrative objects provide context at the beginning and end of each unit. Assignments are the concluding object of each block of instruction (Weller).

Examples of objects that qualify and were provided under the above definitions, terms, constructs, and categories range from simple, noninteractive objects such as text, audio clips, static images, and worksheets (Bing et al., 2006; Kurubacak, 2007; Lee & Su, 2006; Liber, 2005; Sjoer & Dopper, 2006) to more complex and interactive objects including applets, simulations, and data-base driven activities (Bing et al.; Gunn et al., 2005; Heyer, 2006; Kurubacak; Lam et al., 2004; Lee & Su, 2006; Muzio et al., 2002; Poldoja et al., 2006).

With such a variety of understandings of what a learning object is, it is easy to see how reusing objects meeting one system's definition of learning objects may be difficult if not outright impossible for a system with a differing definition.

Merrill-esque Versus Lego-ish

Another aspect of the learning object construct that can differ widely between objects and would effect reusability is whether the object is a self-contained entity, for the purposes of this review—Lego-ish—or a separated combination of content and presentation, for the purposes of this review—Merrill-esque. An obvious example of a Merrill-esque system would be TICCIT (Merrill, 1983), while an example of a Lego-ish object would be a Flash video. The distinction made here between Merrill-esque and Lego-ish is purposeful. In Merrill's different iterations, knowledge is distinctly separated from presentation. A more generic, and possibly more insightful version of this concept is the distinction between XML that holds structured data and an XSLT that does something with the structured data, neither piece is very useful to a learner without the other. Alternatively, a Lego-ish perspective uses complete objects, and often times regardless of whether the objects are instructional or not. The reason I make this distinction is to highlight the fact the Merrill-esque objects can only be used on systems designed to accept their specific interpretation of objects, while Lego-ish objects are more easily transportable but more difficult to customize.

In one article, the author contends that the researchers have separated "knowledge objects" from "instructional objects" because they have two separate flash files, one with a mathematical simulation, the other with a quiz on the mathematical concept (Heyer, 2006). While the two objects in question do have primarily different educational functions (i.e., simulation vs. assessment), each object is a complete and self-sustained object (i.e., a user can use either object as developed, without the other object, making these learning objects Lego-ish).

It is possible to have objects that are both Lego-ish and Merrill-esque; only one article reviewed had such dual-approach objects. Based on the authors' description of interactive ELOs, each object in their study was a complete package with both a presentation template and content, but the templates could be reused with different content (Muzio et al., 2002).

Of the remaining articles where the learning object construct was clear enough to make a determination of whether they were Merrill-esque or Lego-ish, 15 had Lego-ish objects (Bing et al., 2006; Griffiths et al., 2007; Heyer, 2006; Koppi et al., 2005; Krull et al., 2006; Kurubacak, 2007; Lam et al., 2004; Lee & Su, 2006; Liber, 2005; Pegler, 2005; Reilly et al., 2006; Sjoer & Dopper, 2006; Wang & Hsu, 2006; Weinreich & Tompkins, 2006; Weller, 2004) while only seven had Merrill-esque objects (Green et al., 2006; Gunn et al., 2005; Koppi et al., 2005; Lukasiak et al., 2005; Phillips et al., 2004; Poldoja et al., 2006; Ting et al., 2006). Koppi and colleagues had a variety of objects, some of which fell into the Merrill-esque category while others were Lego-ish.

It should be obvious that the disparities in learning object architecture, either encapsulated or separated in multiple layers, preclude the reuse of many learning objects across differently architectured systems.

Reuse

Most of the articles reviewed attempted to teach readers how to do something related to learning objects, whether it be creating better metadata schemes or scheme extensions, create and maintain a repository, create new objects that would be easy to reuse, modify existing objects, or create a course out of existing objects.

Seven of the reviewed articles make proposals for creating, extending, or encouraging the use of metadata schemes (Bing et al., 2006; Heyer, 2006; Krull et al., 2006; Lukasiak et al., 2005) or are purely theoretical (Lee & Su, 2006; Liber, 2005; Lukasiak et al., 2005; Tompsett, 2005). None of these seven articles explicitly discuss reuse.

Two of the reviewed articles discussed learning object repositories. McCormick and Li (2006) surveyed teachers using the Context eLearning with Broadband Technologies (CELEBRATE) repository, but their questions focused on perceptions about learning object usefulness, design, usability and flexibility. There was an implicit expectation of reuse, but with statements such as "… almost 70% of the teachers believed that LOs were useful in teaching …" (McCormick & Li, p. 221) reuse is not actually evident. For example, 1% of teachers may be using 1% of the repository's objects, but through word of mouth, 70% of teachers hear about how useful that 1% of teachers find that 1% of the repository's objects and report that on the survey, while never having used the repository or learning objects themselves. This example is extreme; the problem is that the authors never provide any data about actual reuse. Koppi and colleagues (2005) describe the development and design of their metadata repository, the Learning Resource Catalogue (LRC), but also do not discuss any actual reuse. Neither of these articles provide any empirical, experiential data about the actual reuse of learning objects.

Eleven of the reviewed articles included a learning object creation perspective. Kurubacak and Poldoja created objects to be used in project-based and progressive inquiry designs, respectively (Kurubacak, 2007; Poldoja et al., 2006), Griffiths and Reilly converted existing materials to learning objects (Griffiths et al., 2007; Reilly et al., 2006), Weinreich and Tompkins (2006) created very basic, patient medical profile objects, Weller created objects for one specific course with the intention to use them in another proposed project (Pegler, 2005; Weller, 2004), Phillips and colleagues (2004) created objects that could be easily and massively customized for new university students, Muzio and colleagues (2002) created objects with storage and template reuse as considerations, Lam and colleagues (2004) created objects to support the learning of common Chinese character categorical errors for students at different grade levels, and Sjoer and Dopper (2006) created objects in a collaborative environment as alternative materials for students to access. Ting et al. (2006) developed a framework for medical case scenario-based objects. Of these 11 articles, only three detailed any actual reuse of the objects in an educational environment. In Kurubacak's (2007) article, the reuse *is* the instructional design (i.e. Kurubacak had students combine existing learning objects in a constructivist style learning activity). With both Lam and Weller, the reuse was planned prior to the creation of objects (Lam et al., 2004; Pegler, 2005; Weller, 2004).

While Liber (2005) proposed having teachers modify existing objects to more accurately meet their needs, in Gunn and colleagues (2005) case study, two instructors actually sat down and modified a single, large, database-driven object.

Pegler (2005) and Wang and Hsu (2006) authored the only two articles that were focused primarily on reusing existing objects. Pegler reused the objects that Weller had created in informal staff development courses. Wang and Hsu had postgraduate students—students that had previously participated in designing teaching materials for courses they were tutoring—recreate courses with learning objects the researchers had created for their study; unsurprisingly, it took less time to recreate a course using learning objects prepared specifically for that purpose (Wang & Hsu).

Out of the 25 articles reviewed, only five actually detailed occurrences of learning object reuse. In one case, the reuse scenario was very contrived (Wang & Hsu, 2006), in three cases the reuse was planned before the learning objects were created (Lam et al., 2004; Pegler, 2005; Weller, 2004), in one case an existing object was modified

(Gunn et al., 2005), and in one case the act of reuse was the act of instructional design (Kurubacak, 2007).

Therefore, despite all the talk and article tagging about reuse, reports of studies of actual, “real world” (i.e., not experimentally contrived) reuse of learning objects were basically nonexistent.

Methodologies

The most prevalent research methodology for the articles reviewed was the basic case study, used in seventeen of the 25 articles (Bing et al., 2006; Green et al., 2006; Griffiths et al., 2007; Gunn et al., 2005; Heyer, 2006; Koppi et al., 2005; Kurubacak, 2007; Lam et al., 2004; Lukasiak et al., 2005; Muzio et al., 2002; Pegler, 2005; Phillips et al., 2004; Poldoja et al., 2006; Reilly et al., 2006; Sjoer & Dopper, 2006; Ting et al., 2006; Weinreich & Tompkins, 2006; Weller, 2004). Unfortunately, in many of the case studies, not even the most basic of descriptive quantitative data were provided. Two of the articles had no research methodology, they were simply providing new theories (Lee & Su, 2006; Liber, 2005). One of the articles used a mathematical proof as its methodology (Tompsett, 2005). Two articles used surveys to collect basic qualitative and quantitative data (Krull et al., 2006; McCormick & Li, 2006). One article used a semi-experimental methodology, with the subjects in a controlled environment, replicating a process they had previously performed in an uncontrolled environment (Wang & Hsu, 2006).

The scale of the articles lay at one extreme or the other, with 13 of the articles focused on five or fewer courses (Green et al., 2006; Griffiths et al., 2007; Gunn et al., 2005; Kurubacak, 2007; Lam et al., 2004; Muzio et al., 2002; Pegler, 2005; Poldoja et al., 2006; Sjoer & Dopper, 2006; Ting et al., 2006; Wang & Hsu, 2006; Weinreich & Tompkins, 2006; Weller, 2004), four articles focused on a repository-level perspective (Koppi et al., 2005; Krull et al., 2006; Reilly et al., 2006; Sjoer & Dopper), and one outlier article covering 11 courses that had a total of 20,000 students (Phillips et al., 2004).

Conclusion

Despite all of the articles being from peer-reviewed journals, the overall quality of the articles was less than ideal. A couple of egregious examples are the lack of clear definition or examples of what that particular article considers to be a learning object (McCormick & Li, 2006) and such ambiguity that it is unclear if the authors are basing their comments on other literature, actual user comments, or research (Koppi et al., 2005). Not all of the articles were of poor quality, with three articles standing out from the rest for their clear detailing of their various case studies (Lam et al., 2004; Muzio et al., 2002; Weller, 2004).

Despite the varying quality of these articles, none empirically examined the reuse of learning objects in a way that informs the broader educational community about how reuse is, or is not, occurring outside of controlled research environments. Additionally, when reasons were given for why reuse was or was not occurring, the reasons were speculative and not based on empirical research. Because reuse is the key enabler of most of the hypothesized benefits of learning objects, such empirical studies are desperately needed.

CHAPTER III

METHODOLOGY

Open Educational Resources and Connexions

One subset of learning objects that is easier to reuse is called open educational resources (OERs). OERs are licensed via varying schemes, both individually and as entire repositories, which grant would-be reusers the rights and permissions they need to reuse the objects. For example, a specific owner may license their work with the creative commons attribution license (CC-By), which obligates anyone reusing that content to give attribution credit to the original creator as they do things such as modify the content or reuse it in a commercial environment. Alternatively, a content creator my license their work as creative commons attribution noncommercial no-derivatives license (CC By-NC-ND), which states that attribution must be given, but also that the work cannot be used for commercial endeavors (i.e., it can only be used for *noncommercial* purposes) and cannot be modified to create a derivative product (i.e., it can only be used in a *nonderivative* fashion exactly “as is”).

This distinction in license is important because it may effect whether a potential subsequent user does or does not reuse the content. For example, if an instructor creates an Adobe Flash animation of a basic mathematical concept, including their own school colors and mascot to add motivational context for their students, and releases the resulting .swf—the compiled version of the object—then people who might have seen potential in the instructional aspects of the object, may choose not to reuse it due to the embedded context of the originating school. Alternatively, if the originating instructor released the object under a pro-derivative license and also released the .fla—the Flash source code—then subsequent users are able to modify the school colors and mascot, either to their own institution colors and mascot, or through the removal of the mascot. Obviously, license terms and access to source code play a significant role in the reusability of learning objects.

There are currently more than 85 different OER repositories listed on the site of OER Commons, an organization that harvests and organizes information about OER providers (http://www.oercommons.org/oer/providers). Among the OER Commons provider list, the repository with the most objects available is Rice University's Connexions. Connexions uses the Creative Commons Attribution license across the entire repository, so reuse is very simple from a legal perspective. Connexions also provides easy-to-use tools for the creation of individual objects, which they call "modules," and the aggregation of individual objects into what they call "collections." When creating a collection from within the Connexions' editing tools, it is easy to find and incorporate (e.g., reuse) existing modules. It is also possible to modify existing modules, either (a) through creating a derivative copy or (b) through collaboration with the authors of the existing module. Versions of modules that are translated into another language are also created through the derivative method. As a result of the quantity of existing content, simple tools supporting content reuse, and the derivative-supportive licensing environment, Connexions is an ideal repository within which to empirically evaluate learning object reuse occurring *in the wild*, that is, outside a controlled, experimental environment. Connexions was therefore chosen as the environment in which to carry out the proposed research.

In relation to the previously highlighted distinction between Merrill-esque and Lego-ish objects, Connexions modules are Merill-esque. Modules and collections are stored as presentation-independent XML, and can be presented both as html pages to web users and published as books with completely different formatting.

Research Questions

The primary question for this study was, "*How much and what kind of learning object reuse is currently occurring"?* Additional questions related to the primary research question, that could be answered based on the structure of the Connexions repository and availability of data, included the following.

1. What is the rate of learning object reuse, without modification, within the repository?
2. What is the rate of learning object reuse, without modification, by individuals other than the original authors within the repository?
3. What is the rate of learning object translation within the repository?
4. What is the rate of learning object modification within the repository?
5. What is the rate of all learning object recycling within the repository?

Initial Data Collection and Analysis

Each collection and module in Connexions has metadata. The metadata page for each module and collection includes the object's name, ID, language, summary, subject area, keywords, license, authors, copyright holders, maintainers, creation date and version history. If a collection or module is derived from another collection or module, the metadata also includes the URL, title, and authors of the original object. If a collection or module was translated from another collection or module it had the same information as a derived object plus one or more translators. For each version of an object, the version metadata included the version number, date and time of the changes, and a brief description of the changes. Each collection was also a webpage that lists the modules it contained. Connexions also provided statistics on the number of visitors per day to each module and collection.

For each collection and module, the following information was gathered: object name, object ID, language, count of keywords, license, authors, copyright holders, maintainers, version editors, version count, and creation date. If the object was derived or translated, the original object ID and the translator data was also gathered. Additionally, the module ids associated with each collection id were gathered.

All of the data collected is publicly available and openly licensed. The data gathered is from each object's metadata page (e.g., http://cnx.org/content/col10363/1.3/content_info and http://cnx.org/content/m10856/latest/content_info) and the collection's included module URL (e.g., http://cnx.org/content/col10220/latest/containedModuleIds).

Terminology

There are a variety of kinds of use and reuse to count and quantify. The research examined the following kinds of use and reuse of Connexions modules.

1. Use – A count of each time a module is included in one or more collections without modification (the module is used exactly "as is")
2. Reuse – "Use minus one." By subtracting the original as-is use, we get a measure of as-is reuse.
3. Translation – A count of all derivative modules where the derived module is in a language different from the original
4. Modification – A count of all derivative modules where the derived module is

in the same language as the original

5. Recycled – The simple sum of Reuse, Translation, and Modification
6. All Use – The simple sum of Use, Translation, and Modification

For example, if Professor Biology Scientist creates a module m123: *The Dapple Dilemma* covering the subject of the dapple gene and inbreeding of dogs; then she uses m123 in her collection for an introductory biology course. A second Connexions user is putting together a course on dog breeding and decides to include m123. At this point, m123 has been used in two collections and reused in one collection. One instance of m123's use was by its author, while the subsequent use was by a nonauthor.

There are other types of reuse that could be of importance and need to be accounted for when discussing the concept of learning object reuse. For example, if Professors Spanish Scientist and Chinese Scientist create derivatives of m123 and translate them, the new modules have new module IDs (i.e., they are no longer m123) but their metadata will indicate that they are derivatives of m123 and by comparing their language with the language of m123, it is possible to conclude that they are translations. In the same way, if Professor Biology Scientist is creating a course for her upper level students, she may make a derivative of m123 to use as the basis for a more detailed module on the relationship between dapple genes and inbreeding. Like the Spanish and Chinese translations, this new module will have a new module id as well as metadata indicating it is a derivative of m123, but because the languages between the modules are both the same, it can be concluded that it is simply a modification of the originating module, and not a translation.

To summarize the example, module m123 has now been used twice, reused once, translated twice, and modified once (see Table 1). To separate between "reuse" as defined above and a broader notion of reuse overall throughout the repository, the

Table 1

Recycle Terminology and Examples

Term	Definition	Ex: m123
Use	Count of each inclusion of an originating module in a collection.	2
Reuse	Count of all but the initial use of an originating module as-is in a collection (i.e., Use – 1).	1
Translation	Count of each derivative of an originating module where the language between the modules differs.	2
Modification	Count of each derivative of an originating module where the language between the modules does not differ.	1
Recycled	Count of each reuse, translation, and modification of an originating module.	4
All Use	Count of each use, translation, and modification of an originating module.	5

term "recycle" will be used to include all reuse, translation, and modification; therefore, m123 has been recycled a total of four times. The distinction between all use and just subsequent reuse is important to keep the keep the comparisons between the types of recycle usage parallel. However, some statistics require the initial use of a module be included, therefore, there is also an all-inclusive All Use count.

Using these distinctions, it is possible to have a module that is recycled while never having been used (i.e., there was a translation or modification, but never a inclusion of the originating module in a collection).

Collections, Use, Reuse, and Authorship

To measure reuse within the Connexions repository framework, there were two different data levels: collections and modules. The data collection process gathered three specific sets of collection data: the collection's name, its included modules, and persons related to the module. In Connexions there can be many roles involved in each object's creation, modification, and use. For the purposes of this study, an author included not only the authors of a learning object, but also that object's copyright holder, maintainer, and any editors, but did not include translators. For the related persons data, all user roles, such as author, copyright holder, and version editor, were included. For each module, the base set of information included its title, count of the collections in which it was included, its related persons, its age, its count of keywords, and its number of revisions. Additionally, a list was compiled of every module that was derived from an original module, to include both translated and modified modules.

To identify overall use and to determine the base figure for subsequent reuse calculations, both a sum of all modules (i.e., unique modules published) and a sum of all modules included in at least one collection or used as the originating module for a subsequent derivative module (i.e., unique modules used) were calculated. Since there are many reasons why a module might not be used in a collection, that would also affect the module's likelihood of being reused, such as a module being used to test functionality or a module with outdated information, the latter calculation—unique modules used—was the base figure for many subsequent calculations.

The next figures calculated were related to the actual reuse of modules. Including a module's initial use in a count of reuse would result in erroneous rates of reuse, therefore, for each module, both a use and a reuse count was identified. The Use Count is simply a count of collections that include the specific module; the Reuse Count is simply one less than the Use Count to a minimum of zero (i.e., a module cannot have a reuse count of -1). For example, if module id m123 is used in a total of five collections, its use count would be five, but its reuse count would only be four. Similar to the unique modules used, a count of unique modules reused will also be calculated. For example, if the repository has 150 unique modules used and 10 of those modules are used in more than one collection, the unique modules reused count would be 10.

To identify the frequency of reuse, exclusive of derivations, within the repository two additional calculations were made. First, the reuse percentage of modules was calculated by comparing the total unique modules reused count to the total unique modules used count. Second, the reuse rate was calculated by comparing the total reused count to the total count of modules with any reuse. For example, if there are 100 unique modules used a total of 150 times in collections and 10 of those are reused, then the reuse percentage is 10 (10 reused modules out of 100 used modules) and the reuse rate is 5.0 (10 reused modules reused a total of 50 times).

A factor that may be related to reuse is the participants involved in the creation and maintenance of both the collection and modules. Therefore, persons related to each module were compared to persons related to each collection in which the module was included. For example, if module m123 is included in collections col456 and col789, and there is a shared user account between module m123 and collection col456, but no shared user accounts between module m123 and collection col789, than module m123 would have both an authorship and nonauthorship count of 1. These counts were then summed across all used modules.

Derivatives, Recycling, and All Use

Part of the Connexions repository's functionally is the ease of making derivative copies of modules. Such derivatives include the module id of their originating module. Some of these modules are translated into other languages, while others are simply modified.

Both translated derivatives and modified, untranslated derivatives were counted.

These counts were summarized across the repository, and also had their percentages and rates calculated, in the same way that the Reuse Percentage and Reuse Rate were calculated. To extend the previous reuse example, if there are 100 unique modules used a total of 150 times, with 10 modules modified resulting in a total of 15 modified derivatives, and 10 modules translated resulting in a total of 20 translation derivatives, then the modification and translation percentages would both be 10.0, while the modification rate would be 1.5 and the translation rate would be 2.0.

Once the reuse, modification, and translation data were summarized, a corresponding set of comprehensive recycle calculations were made, resulting in an overall recycled module count, recycled module usage, recycle percentage, and recycle rate. Since it is possible for a single module to have been reused, translated, and modified, the recycled module count may not be the sum of the reuse, translation, and modification counts (because this could count the same original module multiple times). Continuing the previous examples (see Table 2), if module m123 was both reused once and translated once, and m456 was reused once and modified once, then the recycled module count would equal 18 not 20, the recycled module usage would equal 85, resulting in an overall recycle percentage of 18.00 and recycle rate of 4.7.

Table 2

Example Recycle Calculations Table (with a Unique Modules Used Count of 100)

Reuse type	Count	Usage	Percent	Rates
Reuse	10	50	10.0	5.0
Translation	10	20	10.0	2.0
Modification	10	15	10.0	1.5
Recycling	18	85	18.0	4.7

One last reuse summation calculation was made. To compare several subsequent variables of interest to the overall rate of reuse, all forms of recycling and initial use needed to be calculated; therefore, an All Use count was used. All use is the sum of use count, modification count, and translation count. Continuing the previous example where module m123 is reused once and translated once, its all use count would be three (use count of 2 plus a translation count of 1).

At this point, the basic measures needed to examine and discuss the different varieties of reuse with precision, including recycling, modification, and translation, as well as the relationship between collection and module authorship, are identified, defined, exemplified, and ready to use in answering the research questions.

Additional Relationships

To explore possible connections between reuse frequency and other factors, Pearson product correlations were conducted comparing module usage (i.e., each use of a module in a collection) with several other variables of interest.

The first two correlations compared whether the age of the module measured in years, or the number of revisions made to the module, were related to usage. For example, an object that has only been publicly available for a week has had less opportunity to be reused than an object that has been available for several years. Therefore, we may expect to find a relationship between age or maturity variables and reuse variables.

The third correlation compared the total number of persons associated with the module to its usage. If there was a correlation, it might indicate that the number of people involved with the module (authors, copyright holders, maintainers, editors, etc.) is related to the rate of reuse, or that module reusers participate in their maintenance over time.

The last correlation compared the number of keywords to reuse frequency. In this case, a correlation might indicate that modules that have a large quantity of keywords may be easier to locate for subsequent reuse.

For each of the correlation calculations the all use count was used in comparison to the variable of interest.

Challenges

While the data collection methodology described in this chapter remained true to the submitted proposal, analyses of the data evolved. The most challenging aspects of the analysis evolution involved simultaneously accounting for all uses, reuses, translations, and modifications of a module without recursive accounting and subsequent comparison. A result of this evolution is the overlap in how a module, including its derivatives, can be counted. While this overlap does generate some recursive and potentially confusing terminology, it provides necessary precision and a replicable methodology.

Another challenging aspect was adapting the methodology after an early, unexpected finding highlighted an unstated assumption. This finding and its impact is covered in the results chapter, but its discovery also improved the methodology.

CHAPTER IV

RESULTS

This study was designed as an analysis of learning object reuse, including the collection of descriptive quantitative data about module reuse and identification of correlations between reuse and variables that might provide insight into reuse. The three large areas of data collection and analysis focused on specific modules, modules derived from other modules, and additional variables that might provide insight.

Collections, Use, Reuse, and Authorship

A critical, unstated assumption made by the researcher turned out to be false, but its identification is, in and of itself, an important finding. Specifically, the researcher assumed that there was significant use of Connexions modules within Connexions collections. Because the study goal was descriptive quantitative data, this was not a fatal flaw and its early identification resulted in important methodological revisions.

Prior to the formal data analysis, a preliminary analysis was conducted to ensure raw data was not compromised in the collection process. This analysis resulted in identification of modules not included in any collection. The total count of Unique Modules Published was 5,221, but the total count of unique published Connexions modules that were used in any collection or as the originating module for another derivative module (i.e., unique modules used), was only 3,519. In other words, 32.6% of modules published in the Connexions repository are not used at all. A convenience sample of these modules was analyzed. Some were published "dummy" modules, such as m12189:*Fred's day off* that is credited to Fred Flintstone; some were clearly never completed, such as m10457:*adaptive filters* that had no content; and others were outdated, such as m10553:*homework B* that had its content merged with content from another module—outside of Connexions—and used to create a derivative that subsequently could not be automatically tracked.

The initial analysis also identified 18 modules that were not used in collections, but a subsequent derivative or translated module was used in a collection. These modules were included in the unique modules used count.

The next calculations were the count of how many times modules were included in any collection (i.e., the total use count), which was 4,713, the count of how many times an individual module exceeded an initial use (i.e., the total reuse count), which was 967 times, and the count of modules that were used in two or more collections (i.e., the total unique modules reused), which was 724. These calculations indicated a reuse of discrete modules as 20.57% of the unique modules used, with a reuse rate of 1.34 times for each reused module. See Table 3 for this data, as well as the recycle related data discussed next.

The last set of data related to specific modules usage is the relationship between people involved in a module and its containing collection. For each instance of a module being used in a collection, either the module had one or more persons in common

Table 3

Module Recycling Summary

Reuse type	Unique modules	Uses	Percentage	Rates
Reuse	724	967	20.57	1.34
Translation	105	174	2.98	1.66
Modification	101	120	2.87	1.19
Recycling	861	1,262	24.47	1.47

Note. Unique Modules Used = 3,519
Total Use Count = 4,713

between them, known as the author count, or there were no common persons (i.e., the nonauthor count). There was a common author in 3,722 module uses, while there were only 1,013 module uses where there was no common author (see Figure 2). This means that modules were included in collections 3.67 times more often when there was at least one person in common with both the module and the collection.

Derivatives, Recycling, and All Use

The next set of data analyzed related to the derivative functionality that Connexions supports. In this case, the data were mined to determine if any other modules were based on the specific, originating module. If there were derivative modules, they were separated into translation and modification derivatives and counted.

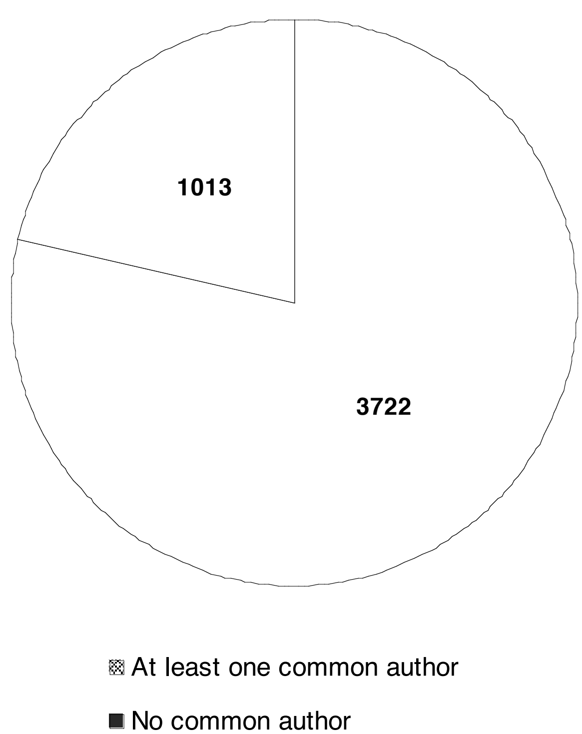


Figure 2. Authorship relationship between modules included in collections.

Therefore a module that was the basis for four derivative modules, and three of those were translated, would have a Translation Count of three and a Modification Count of one. As mentioned previously, 18 modules were never used in a collection, but were the originating module for subsequent translation and modification derivative modules (see Appendix A).

As shown in Table 3, of the 3,519 unique modules used, 105 were translated into 174 derivatives, while 101 were modified into another 120 modules. Because a module might be recycled in multiple ways, the recycle unique module count is not a summation of the reuse, translation, and modification unique module counts. There were 50 modules that were recycled in multiple ways; of these, six modules were reused, translated, and modified; 16 modules were reused and modified; 26 modules were reused and translated; and only two were modified and translated without reuse of the originating module. For more details, see Appendix B.

Ultimately, of the 3,519 modules used in Connexions, 861 of them were recycled in some way for a total of 1,262 uses. This means that almost a quarter of all modules that were used at all were recycled. Between basic reuse, translated derivatives, and modified derivatives, recycled modules were used almost 1.5 times beyond their originating object's initial use. Figure 3 provides a summary of the overall use and reuse of learning objects in the Connexions repository.

Correlations and Qualitative Recycling Data

There was no significant correlation between recycling of modules and their age, number of persons involved with the module, number of keywords, and number of revisions (see Table 4).

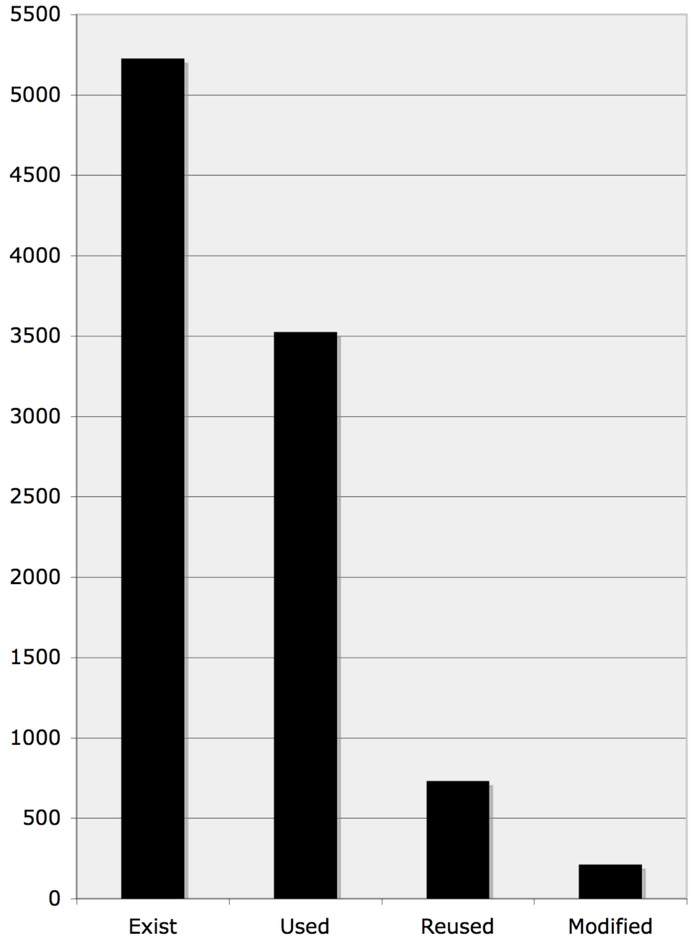


Figure 3. Unique Connexions modules.

Table 4

Correlations with All Use

Pearson product moment (*n* = 3,519)	r^2	*SD*
Person count	0.0185	2.0166
Age in years	0.1312	1.908
Keyword count	0.0006	5.2603
Version count	0.0344	3.9306

There were 15 modules that were used, translated, or modified more than five times (see Table 5). Of these, the module that was used most, without translation or modification, was m13757: *Three frame works for ethical decision making and good computing reports*. This module was used in seven collections (see Table 6), two of which are demonstration collections that are unrelated to the content of the module. The other five collections are part of a series called *Ethics Across the Curriculum (EAC)*.

Table 5

The 15 Modules Recycled More Than Five Times

ID	Name	All use	Use	Modified	Translated
m10620	Multirate filtering: Theory exercise	10	6	1	3
m10815	Multirate filtering: Filter-design exercise in MATLAB	9	5	1	3
m13757	Three frameworks for ethical decision making and good computing reports	7	7	0	0
m10481	Adaptive filtering: LMS algorithm	6	6	0	0
m11948	Review of linear algebra	6	6	0	0
m10813	IIR filtering: Filter-coefficient quantization exercise in MATLAB	6	5	1	0
m14789	Toysmart case exercises - student module	6	5	1	0
m10549	The Z transform: Definition	6	5	0	1
m10556	Understanding pole/zero plots on the z-plane	6	5	0	1
m10595	Difference equation	6	5	0	1
m9007	The advanced CNXML	6	3	2	1
m10681	Preface for U of I DSP laboratory	6	3	0	3
m10621	Multirate filtering: Implementation on TI TMS320C54x	6	2	1	3
m14290	EAC toolkit: Instructor module template	6	0	6	0
m14291	EAC Toolkit: Student module template	6	0	5	1

Table 6

Collections Including the Most Reused Module

ID	Name
col10278	PDF generation test course
col10396	Corporate governance
col10399	Professional ethics in engineering
col10411	Ethics bowl competition as capstone activity for practical and professional ethics classes
col10423	Modules linking to computing cases
col10491	Business ethics
col10514	PDF generation problem modules

Four other modules in the top 15 are from the same series (i.e., m13757, m14789, m14290, m14291). The last two modules, of the EAC series, are not parts of any collection; they were used to derive eleven subsequent modified modules and one translated module.

With one exception, 10 of the remaining top 15 modules were reused in the same 11 collections (i.e., m10620, m10815, m10481, m11948, m10813, m10549, m10556, m10595, m10681, and m10621; see Appendix C) and were all related to digital signal processing (DSP). Module m1148:*Review of linear algebra* was used in one demonstration (i.e. content irrelevant, collection, and in one signal processing course that did not include the other nine DSP modules).

The one remaining module, m9007:*The advanced CNXML*, is a module on using the Connexions specific XML known as CNXML.

Summary

A third of modules were never used in a collection or as an originating module for derivatives or translations. Approximately a quarter of distinct modules that were used, were also recycled. These recycled modules accounted for slightly more than a quarter of all module usage. There were no significant correlations between reuse and the number of module-related people, number of keywords, age of the module, or its revision frequency. An analysis of the fifteen most recycled modules, each accounting for more than five module usages, showed (a) Connexions-specific usage or content or (b) common collections and collection themes.

CHAPTER V

CONTRIBUTIONS, LIMITATIONS, AND FUTURE DIRECTIONS

This study collected empirical data on learning object reuse in situ, is also defined other categories of learning object recycling, and identified an unforeseen scenario in need of further research (i.e., the lack of learning object *use)*.

Methodology and Terminology

One of challenges facing an emerging field is that of terminology and methods. There is already an overabundance of (often times) disparate definitions for the learning object construct. However, these definitions have most often included the construct of reuse as a key characteristic. While this study has not attempted to contribute to the dialog on the definition of learning objects, the study has added clarity to the core reuse construct itself and expanded the reuse construct to include other more specific forms of recycling, and has identified a preliminary quantitative methodology to analyze several forms of recycling. Clearly, as more research is done, the different recycle-related constructs will be further refined, as will the research methodology.

Use Versus Reuse

Both the most unexpected and the most curious finding is that 32.6% of modules published in Connexions are not used at all. This researcher cannot help but wonder if there is a relationship between this lack of first use and the lack of subsequent reuse; specifically, if almost a third of published learning objects in a repository are, for whatever reason, not usable, does their existence frustrate potential reusers during searches for more usable material (i.e., their searches result in bogus or useless modules) ? If so, does this frustration affect subsequent efforts to reuse existing material?

Egocentrism

Related to the previously topic, is reuse by authors, as opposed to nonauthors, so extensive simply because they know what exists in their own content, or is there a bias to use one's own work (i.e., a "not-created-here" attitude even among those who extol the virtue of reuse)? The fact that a person is creating a collection within an OER repository might indicate a greater willingness to use someone else's creation, but it certainly is not guaranteed. It is possible that the person using an OER is motivated by the free hosting of content or the proliferation possibilities for their own content.

Further, within certain contexts (such as higher education), it is important to receive credit for work done, and there are expectations for the quantity of contribution. For example, published articles in peer-reviewed journals count toward tenure and being first author on such an article carries more weight than being a secondary author. In a similar vein, is there an inherent expectation that an author will make substantial changes to an existing object to receive social credit for the contribution? In other words, is there social pressure to create new objects, or to radically differentiate modified objects, such that there is a corresponding pressure not to reuse or to cooperatively make minor changes to existing objects? In the analysis of a wiki-based programming contest, it was noted that, "Initially most people find tweaking [minor modifications] distasteful or even parasitic, particularly those who have been tweaked out of first place. But tweaking turns out to be the fuel that drives the entire contest" (Gulley, 2004). One of Gulley's statements that resonates with the concept of learning object recycling is that “No improvement is too small to be worthy of consideration.”

The relationship between an author’s reuse of their own versus others’ learning objects is a potentially critical area of study, specifically, in relation to studies of innovation adoption (Rogers, 2003). For example, is there a relationship between adopter status and type of learning object use (e.g., is someone who is an early adopter of learning objects more likely to create learning objects while someone in the early majority is more likely to reuse existing learning objects)? If there is such a relationship, is it possible that there are two different adoption rates for learning objects (i.e., a learning object creation adoption rate and a learning object reuse adoption rate)?

Limitations

Since this study was the first attempt to quantifiably evaluate the reuse of learning objects many assumptions and constraints existed. One of the biggest constraints was the construct itself; specifically, this study limited analysis to content that unambiguously qualified as *learning objects* and then further constrained that definition to a single repository. If the construct remains as it was in this study, but subsequent study explicitly analyzed use and reuse in a closed repository, such as a Department of Defense or corporate repository, where learning object use is required, the results will likely be very different. One of the benefits of using the Connexions repository was the open data about the different modules and collections. While this was open data was critical for this study, the study was also limited to the available data, and this limitation will be true for any repository studied. For example, while some authors’ institutional affiliation could be assumed based on the email address associated with their Connexions user account, not all users used an institutional email address; this lack of comprehensive institutional affiliation limited potential analysis between collection and module authorship (e.g., if a graduate assistant specifically authored all of the modules *for* a professor who subsequently authored the collection, would that be a type of egocentric use). Likewise, other repositories, open content, military, corporate, or otherwise, will have their own benefits and limitations.

If the construct had been expanded to include any digital learning content with an open license, the results would also likely be drastically different. For example, this study itself will be both open licensed and made into a Connexions module; as open-licensed content, it may be used in many ways that currently prevent easy or dependable tracking and as a result, if someone subsequently replicates this study without altering and augmenting the methodology, this study's Connexions module may appear neither used or reused. Potential methods to overcome some of these limitations include analysis of *blog track-backs* (i.e., web of science-like reverse referencing for blogs), use of technology like Google's "link:" search operator (e.g., reverse linking for a selected URL), and software designed to identify plagiarism in texts.

Next Steps/Areas for Further Research

There are three prominent categories of next steps to this work. First, future researchers must identify the expected benefits of reuse to determine the true importance of reuse. Second, future researchers must replicate and expand the current study to determine Connexions idiosyncrasies, expand on the qualitative nature of the findings in new repository contexts, and establish quantifiable measures to assess adoption rates. Third, future researchers must reevaluate the learning object construct in light of reusability data.

Ultimately, it is crucial for the field of educational technology and instructional systems to determine whether there is an inherent benefit in promoting extensive reuse of content and in expending the resources necessary to prepare for possible future reuse. This researcher believes there are benefits in reuse and in other forms of content recycling; but perhaps these benefits lay not in emphasizing piecemeal reuse, but rather in a combination of factors, including: partnerships to develop content that is useable in multiple, but similar contexts (e.g., content objects for introductory college biology courses) and encouraging recycling of content (e.g., your object is not quite what I need, but your content is open and therefore I can modify it to meet my needs). If it is determined that that there are inherent benefits in extensive reuse, then other questions must be answered to determine why reuse is not more common. Such research should look at both technical and social factors that encourage or discourage reuse. For example, in conjunction with the current focus on journal article authorship, perhaps there is a need for an ongoing educational ecological cooperation rating, a kind of carbon footprint for instructional technologists.

By considering learning resources in the way we consider other resources, we can start to see the benefits of an active environmentalism approach to help our educational ecology reach a productive level. For example, while digital materials can be copied and distributed with little cost, the creation of materials is still limited by many factors including time, materials, and knowledge. If we can find a way to outright reuse existing content, that means additional time and materials do not have to be utilized; other forms of recycling do not have the same return on investment, but they still represent possible improvements on the current approaches. While things such as copyright and proprietary formats are being talked about as inhibitors of reuse, if a potential reuser cannot find the appropriate materials in an expeditious manner, reuse will not happen either. Imagine trying to find a specific working headlight in a large junkyard; such a recycling attempt is probably more costly than just going to the local auto store and buying a new one. In the same way, if the educational world is littered with half-completed, outdated, or otherwise unusable material that has to be sorted through—without reasonable assurance that the desired content even exists—recycling of materials is going to be hampered.

Furthermore, we must prevent members of academia from either not being encouraged or blatantly discouraged to reuse materials, either through a lack of incentives or actual punitive actions (e.g., a tenure-track professor is denied tenure because he/she is not first author on a specified number of peer-reviewed, journal published articles). While the current tenure process is arguably successful at encouraging researchers to *build upon* existing research, there is still an expectation of completing whole studies, authoring polished articles, and publishing in traditional journals. Professors who encourage open cooperation and collaboration between themselves, their students, and others may prefer to use nonstandard methods, such as blogs and wikis, to collaborate and document their findings. This fine-grain approach to sharing the most up-to-date learning content could potentially include much more material than the more traditional approaches, for example, when the research team is preparing their study, they can post the proposal itself to a blog and get feedback from a wide community. Such an approach is currently not beneficial at tenure time; and time spent pursing such nontraditional approaches may reduce time spent pursuing traditional approaches, which can actually be detrimental at tenure time.

An educational ecological cooperation rating could be based on how often a user has reused other peoples work or made minor alterations to existing materials, how often they provide reviews of other peoples' content, and other similar metrics that focus less on wholesale creation of new, large-scale, polished materials, and instead focus more on how a user cooperatively participates in recycling of educational content. Having the educational ecology community review existing content provides the benefits of more traditional peer-review processes, but can also provide additional metadata and metrics about the content which can facilitate weeding out outdated or pure garbage content.

If reuse is seen as beneficial, the next step should replicate this study with other repositories, including at least one other OER repository, but also some corporate and military repositories, to identify patterns of use and recycling that transcend the repository analyzed in this study.

Subsequent steps should include a thorough qualitative comparison of used versus unused content, as well as a comparison of users versus non-users. Without understanding why content exists in a repository without being used, it is difficult to hypothesize about reuse. Specifically, is the lack of recycling related to the lack of initial use, or are there different factors in relation to use versus recycling? There should also be a thorough qualitative comparison of authorship usage versus nonauthorship usage. Is the difference between using one's own content an artifact of personal bias, ease of locating appropriate existing material, rate of personal innovation adoption, or some other factor/s? Additionally, the quantitative metrics developed in this study should be refined and expanded. Future studies that evaluate learning object adoption should also evaluate whether there is a critical mass of learning objects which when met leads to a tipping point in use and reuse.

Finally, if our field is going to emphasize 'reusability' as the primary purpose of learning objects, then it is paramount that we either agree on a definition of the learning object construct—or remove *learning object* from our vocabulary. As long as we each have our own meaning—and these meanings are as diverse as they currently are—we will not be able to truly focus on reusing one another's learning objects. Additionally, as long as we are focusing on reusing items that are defined as *learning objects* we are going to miss many other opportunities to use and reuse quality learning content that is not specifically referred to as *learning objects.* Potential studies could use existing software designed to identify plagiarism as a means of identifying other forms of reuse, including intentional reuse of materials with open licenses. Perhaps, ultimately, the dialog should move from arguments about "what is a learning object?" to discussions of "how do I adapt and reuse existing learning content?"

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APPENDICES

Appendix A

Modules Never Used in a Collection, but Used for Derivatives

Table A-1

Modules Never Used in a Collection, but Used for Derivatives

ID	Name	Modified	Translated
m14291	EAC toolkit:- Student module template	5	1
m14290	EAC toolkit: Instructor module template	6	0
m14029	Ethics toolkit: Open module template	3	0
m13452	Assignments: Section sample	2	0
m10659	Digital transmitter: Introduction to frequency shift keying	2	0
m13150	Conclusion	2	0
m15454	Building an ethics module for business, science, and engineering students	1	1
m12788	Teaching media processing in processing	0	1
m10550	Difference equations	0	1
m10662	Digital transmitter: Processor optimization exercise for frequency shift keying	1	0
m10844	Vector basics	0	1
m11407	Discrete: Time complex exponential	0	1
m12099	The MSP430F16x deluxe development board	1	0
m9003	CNXML 0.5 stress test	1	0
m12391	Spectrum analyzer: Processor exercise using C language with C introduction	1	0
m13430	Course 1, Chapter 4: Theories of and approaches to learning	1	0
m13460	Ethical decision making in engineering (old version update pending)	1	0
m12137	Glossary	1	0

Appendix B

Table of Modules Recycled In More than One Way

Table B-1

Modules Recycled In More than One Way

ID	Name	Recycled	Reused	Modified	Translated
m10620	Multirate Filtering: Theory Exercise	9	*5*	*1*	*3*
m10815	Multirate Filtering: Filter-Design Exercise in MATLAB	8	*4*	*1*	*3*
m9007	The Advanced CNXML	5	*2*	*2*	*1*
m10621	Multirate Filtering: Implementation on TI TMS320C54x	5	*1*	*1*	*3*
m13056	Importing Microsoft Word Documents	4	*2*	*1*	*1*
m9000	The Basic CNXML	4	*2*	*1*	*1*
m10813	IIR Filtering: Filter-Coefficient Quantization Exercise in MATLAB	5	*4*	*1*	0
m14789	Toysmart Case Exercises - Student Module	5	*4*	*1*	0
m10480	Audio Effects: Using External Memory	4	*3*	*1*	0
m10483	Audio Effects: Real-Time Control with the Serial Port	4	*3*	*1*	0
m11019	DSP Development Environment: Introductory Exercise for TI TMS320C54x (ECE 420 Specific)	4	*2*	*2*	0
m10623	IIR Filtering: Filter-Design Exercise in MATLAB	4	*3*	*1*	0
m11021	IIR Filtering: Exercise on TI TMS320C54x (ECE 320 specific)	3	*2*	*1*	0
m10625	Spectrum Analyzer: MATLAB Exercise	3	*2*	*1*	0
m10806	Addressing Modes for TI TMS320C54x	3	*2*	*1*	0
m11020	FIR Filtering: Exercise for TI TMS320C54x (ECE 320 specific)	3	*2*	*1*	0
m13758	Theory-Building Activities: Rights	3	*2*	*1*	0
m14408	Ethical Leadership Using "Incident at Morales"	3	*2*	*1*	0
m11810	Multirate Filtering: Implementation on TI TMS320C54x	2	*1*	*1*	0
m13252	Graphical representation of data in MATLAB	2	*1*	*1*	0
m12380	DSP Optimization Techniques	2	*1*	*1*	0
m12379	Spectrum Analyzer: MATLAB Exercise	2	*1*	*1*	0
m10549	The Z Transform: Definition	5	*4*	0	*1*

(*table continues*)

ID	Name	Recycled	Reused	Modified	Translated
m10556	Understanding Pole/Zero Plots on the Z-Plane	5	*4*	0	*1*
m10595	Difference Equation	5	*4*	0	*1*
m10681	Preface for U of I DSP Laboratory	5	*2*	0	*3*
m13050	Getting a Connexions Account	4	*3*	0	*1*
m11837	Viewing Connexions Content	4	*1*	0	*3*
m10760	Orthonormal Basis Expansions	4	*3*	0	*1*
m13049	Setting Up a Workgroup	4	*3*	0	*1*
m9002	XML Basics	3	*2*	0	*1*
m9006	The Intermediate CNXML	3	*2*	0	*1*
m9008	Content MathML	3	*2*	0	*1*
m13053	Additional Connexions Information Sources	3	*2*	0	*1*
m11215	CNXML Reference Extensions	3	*2*	0	*1*
m10887	Editing Modules	3	*1*	0	*2*
m10840	Hilbert Spaces	3	*2*	0	*1*
m10548	Filter Design using the Pole/Zero Plot of a Z-Transform	2	*1*	0	*1*
m2102	Properties of Systems	2	*1*	0	*1*
m10622	Region of Convergence for the Z-transform	2	*1*	0	*1*
m12614	Programmare in Processing	2	*1*	0	*1*
m10744	Periodic Signals	2	*1*	0	*1*
m0009	Discrete-Time Signals	2	*1*	0	*1*
m10764	Haar Wavelet Basis	2	*1*	0	*1*
m10593	Rational Functions	2	*1*	0	*1*
m10757	Cauchy-Schwarz Inequality	2	*1*	0	*1*
m13055	Revising Your Content in Connexions	2	*1*	0	*1*
m13054	Publishing a Document in Connexions	2	*1*	0	*1*
m10884	Introduction to Connexions	3	0	*1*	*2*
m10766	Approximation and Projections in Hilbert Space	2	0	*1*	*1*

Appendix C

Common Collection Relationships for Recycled Modules

Table C-1

Common Collection Relationships for Recycled Modules

ID	Module name	ID	Collection name
m11948	Review of Linear Algebra	col10514	PDF Generation Problem Modules
m11948	Review of Linear Algebra	col10446	Fundamentals of Signal Processing(thu)
m10556	Understanding Pole/Zero Plots on the Z-Plane	col10446	Fundamentals of Signal Processing(thu)
m10549	The Z Transform: Definition	col10446	Fundamentals of Signal Processing(thu)
m10595	Difference Equation	col10446	Fundamentals of Signal Processing(thu)
m11948	Review of Linear Algebra	col10422	Signal and Information Processing for Sonar
m10481	Adaptive Filtering: LMS Algorithm	col10397	Digital Signal Processing Laboratory (ECE 420 55x)
m10815	Multirate Filtering: Filter-Design Exercise in MATLAB	col10397	Digital Signal Processing Laboratory (ECE 420 55x)
m10620	Multirate Filtering: Theory Exercise	col10397	Digital Signal Processing Laboratory (ECE 420 55x)
m10813	IIR Filtering: Filter-Coefficient Quantization Exercise in MATLAB	col10397	Digital Signal Processing Laboratory (ECE 420 55x)
m10595	Difference Equation	col10372	Digital Signal Processing: A User's Guide
m10556	Understanding Pole/Zero Plots on the Z-Plane	col10372	Digital Signal Processing: A User's Guide
m10549	The Z Transform: Definition	col10372	Digital Signal Processing: A User's Guide
m11948	Review of Linear Algebra	col10372	Digital Signal Processing: A User's Guide
m10556	Understanding Pole/Zero Plots on the Z-Plane	col10360	Fundamentals of Signal Processing
m11948	Review of Linear Algebra	col10360	Fundamentals of Signal Processing
m10595	Difference Equation	col10360	Fundamentals of Signal Processing
m10549	The Z Transform: Definition	col10360	Fundamentals of Signal Processing
m10813	IIR Filtering: Filter-Coefficient Quantization Exercise in MATLAB	col10236	Digital Signal Processing Laboratory (ECE 420)
m10481	Adaptive Filtering: LMS Algorithm	col10236	Digital Signal Processing Laboratory (ECE 420)
m10815	Multirate Filtering: Filter-Design Exercise in MATLAB	col10236	Digital Signal Processing Laboratory (ECE 420)
m10620	Multirate Filtering: Theory Exercise	col10236	Digital Signal Processing Laboratory (ECE 420)

(*table continues*)

ID	Module name	ID	Collection name
m11948	Review of Linear Algebra	col10232	Statistical Signal Processing
m10620	Multirate Filtering: Theory Exercise	col10227	DSP Laboratory with TI TMS320C54x (International Demo)
m10681	Preface for U of I DSP Laboratory	col10227	DSP Laboratory with TI TMS320C54x (International Demo)
m10621	Multirate Filtering: Implementation on TI TMS320C54x	col10227	DSP Laboratory with TI TMS320C54x (International Demo)
m10815	Multirate Filtering: Filter-Design Exercise in MATLAB	col10227	DSP Laboratory with TI TMS320C54x (International Demo)
m10481	Adaptive Filtering: LMS Algorithm	col10225	ECE 320 Spring 2004
m10620	Multirate Filtering: Theory Exercise	col10225	ECE 320 Spring 2004
m10815	Multirate Filtering: Filter-Design Exercise in MATLAB	col10225	ECE 320 Spring 2004
m10813	IIR Filtering: Filter-Coefficient Quantization Exercise in MATLAB	col10225	ECE 320 Spring 2004
m10595	Difference Equation	col10203	Intro to Digital Signal Processing
m10481	Adaptive Filtering: LMS Algorithm	col10203	Intro to Digital Signal Processing
m10556	Understanding Pole/Zero Plots on the Z-Plane	col10203	Intro to Digital Signal Processing
m10549	The Z Transform: Definition	col10203	Intro to Digital Signal Processing
m10681	Preface for U of I DSP Laboratory	col10096	ECE 320 - Spring 2003
m10481	Adaptive Filtering: LMS Algorithm	col10096	ECE 320 - Spring 2003
m10620	Multirate Filtering: Theory Exercise	col10096	ECE 320 - Spring 2003
m10813	IIR Filtering: Filter-Coefficient Quantization Exercise in MATLAB	col10096	ECE 320 - Spring 2003
m10620	Multirate Filtering: Theory Exercise	col10078	DSP Laboratory with TI TMS320C54x
m10681	Preface for U of I DSP Laboratory	col10078	DSP Laboratory with TI TMS320C54x
m10815	Multirate Filtering: Filter-Design Exercise in MATLAB	col10078	DSP Laboratory with TI TMS320C54x
m10621	Multirate Filtering: Implementation on TI TMS320C54x	col10078	DSP Laboratory with TI TMS320C54x
m10481	Adaptive Filtering: LMS Algorithm	col10078	DSP Laboratory with TI TMS320C54x
m10813	IIR Filtering: Filter-Coefficient Quantization Exercise in MATLAB	col10078	DSP Laboratory with TI TMS320C54x
m10556	Understanding Pole/Zero Plots on the Z-Plane	col10064	Signals and Systems
m10549	The Z Transform: Definition	col10064	Signals and Systems
m10595	Difference Equation	col10064	Signals and Systems

VITA

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EDUCATION

2009, Utah State University — Logan, UT
Candidate – Doctor of Philosophy – Instructional Technology

2002, Florida State University — Tallahassee, FL
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PROFESSIONAL EXPERIENCE

October 2008 – Present, Southwest Research Institute — Layton, UT

Instructional Specialist

- Project Manager for the Questioning Model Research project. This project is using Conversation Analysis, critical analysis and reasoning processes to develop a questioning model for interviewers that are gathering tacit knowledge from experts.

- Project Manager leading more than a dozen Expert Knowledge Transformation projects at Hill and Warner-Robbins Air Force Bases.

August 2004 – December 2008, Utah State University — Logan, UT

Graduate Research Assistant, Center for Open and Sustainable Learning

- Doctoral researcher conducting an analysis of learning objects, specifically open educational resources, reuse within the Connexions repository.

- Team member in the design and development of Annorate, a social bookmarking tool with annotation functionality. Annorate is to be integrated into another tool named Pheromone. Pheromone is designed to record social traversal and rating of web-based materials to facilitate traversal recommendations for subsequent students. This Web2.0 tool provides a practical means for informal, socially-supported learning.

- Designer and developer of a template kiosk in Second Life. This template kiosk was used in student projects for an Instructional Technology Foundations course. The student projects were to customize the kiosk to provide information on VIPs within the instructional technology field. The kiosk supports basic delivery of a text document, menu driven access to basic textual information about the student's VIP, and a minimal conversation capability with a simulated graphical representation of the VIP. The kiosk was designed to be both innovative and a practical way for students to practice their instructional design and development skills. An internal evaluation was conducted during the conclusion of the course to help improve subsequent students' experiences.

- Team member in the design, development, and evaluation of Voices of Spoon River, an open source interactive fiction game set in the world of Edgar Lee Master's Spoon River and designed for use in middle and high school English courses, using best practices in educational objectives, instructional design, and game design. Since our initial evaluation, all the 7th grade teachers in the school have adopted this game for their Spoon River and poetry lessons and students have voluntarily downloaded and played the game with family members and friends. [Voices of Spoon River is freely available from http://cle.usu.edu/CLE_IF_VOSR.html]

- Team member in the deployment of course content in Utah State University's OpenCouseWare.

- Team member in the evaluation and bug testing of eduCommons – OpenCourseWare Management System.

<u>2006/2007 President, Instructional Technology Student Association</u>

- Initiated the first Professor Presentation series. [Recordings accessible from http://itsacast.blogspot.com/2006/10/fall-2006-professor-presentation.html]

- Committee member in developing an official student and alumni relations sub-committee.

- Developing a new type of journal. This new journal, geared toward graduate students in the instructional technology field, will feature a unique two-tier approach. Anyone may submit an article, and any registered members may access, vote on, and give feedback on the submissions. The highest rated submissions will then officially be published. This model is designed to allow graduate students the experience of being reviewed, with access to all of the review comments, as well as being reviewers. (This is ongoing past the term of my presidency.)

- Re-initiated Informal Evenings with professors. These evenings are held at professors' houses and provide students an opportunity to discuss topics, with their peers and senior faculty, that they are hesitant to discuss with their own academic advisors.

September 2000 – July 2004, Florida State University Tallahassee, FL

Computer Research Specialist, Learning Systems Institute, Naval Education and Training Command – Personnel Qualification Standards

- One of three team leaders for a project conducting needs analysis and design of an EPSS which assists subject matter experts in the development and revision of Personnel Qualification Standards (PQS) for the U.S. Navy.
- Lead team member for planning and EPSS development, in accordance with Navy specifications and internal design documents.
- Responsible for the development and application of learning object theory, application and related industry standards and practices related to project work.

Graduate Research Assistant, Learning Systems Institute, Chief of Naval Education and Training – Changing Course & Evaluating the Course

- Team member in the design of two EPSSs: one which assists subject matter experts in the reengineering of existing courseware to web-based delivery; one which assists subject matter experts in the review of existing web-based courseware to recommend adoption, adaptation, or rejection of courseware for use by the organization.
- Responsible for the development and application of learning object theory, application, and related industry standards and practices related to project work.
- Responsible for ensuring Sharable Content Object Reference Model (SCORM), version 1.1, compliance on two web-based courses through testing, evaluation, and recoding of all related materials. Also responsible for evaluation of SCORM, version 1.2, compliance on one course.
- Responsible for ensuring all elements of course design and EPSS design were Section 508/accessibility compliant.

Graduate Research Assistant, Center for Performance Technology

- Team member responsible for analysis of statistical data from occupational surveys.
- Team member responsible for converting an existing Filemaker Pro database to Microsoft Access. This also included designing the new user interface and implementing appropriate security measures.
- Team member responsible for conducting assessments and designing a knowledge management system including the specification of appropriate protocols for its use.

October 2001 – January 2002, Florida State Department of Education Tallahassee, FL

Contractor

- One of two contractors responsible for creating the user interface, process automation, and data processing engine to manage and summarize annual data tables using Microsoft Access and Visual Basic.

- Resulted in a Davis Productivity Award, an award to "… recognize and reward state government employees whose work significantly and measurable increase productivity and promotes innovation to improve the delivery of state services and save money…"

April 1999 – May 2000, Blue Ridge Community College Weyer's Cave, VA

Assistant Instructional Technologist

- Team member with responsibility for assisting instructors in the design, development, and deployment of web-based courses.

- Team member with responsibility for assisting students having difficulty with web-based courses.

April 1991 – March 1996, United States Marine Corps,
Camps LeJeune, Butler, and Pendleton

Traffic Management Specialist & Military Police

- Marine responsible for conducting weekly in-house training for 30 Marines as well as ensuring 300 Marines successfully completed all training requirements.

- Marine responsible for developing a Lotus Approach database to track scheduling and completion of the 20+ various training requirements for 300 Marines.

TEACHING EXPERIENCE

Fall 2004	Foundations in Instructional Technology	Teaching Assistant
Fall 2003	Computer Applications for Instruction and Training	Instructor
Summer 2003	Computer Applications for Instruction and Training	Teaching Assistant
Fall 2000	Descriptive and Inferential Statistics	Teaching Assistant
Summer 2000	Descriptive and Inferential Statistics	Teaching Assistant

PUBLICATIONS & PRESENTATIONS

- Duncan, S. M., Foundations of Instructional Technology Second Life Kiosk, 1st Edition, Second Life - OpenEd Island, Unpublished, Autumn 2006
- Scoresby, Jon, Duncan, S. M., Shelton, Brett E. (Jun 15-16, 2006) Voices of Spoon River: Exploring early American poetry through computer gaming, Games, Learning & Society 2006, Madison, WI
- Scoresby, Jon, Duncan, S. M., Shelton, Brett E. (Jun 1-2, 2006) Considering different approaches to teaching using computer games in the classroom, UVSC: Teaching with Technology Idea Exchange 2006, Orem, UT
- Duncan, S. M., Scoresby, Jon, Shelton, Brett E. (Feb 22, 2006) Voices of Spoon River: Evaluation of an educational interactive fiction game, Philadelphia Area Educational Technology Conference (PAECT), Bryn Mawr, PA
- Duncan, S. M., Shelton, Brett E. (Feb 22, 2006) Voices of Spoon River: Study of the development of an educational interactive fiction game by instructional game students, Philadelphia Area Educational Technology Conference (PAECT), Bryn Mawr, PA
- Duncan, S. M., Stowell, Tim, Allen, Bobbe, Shelton, Brett E. (Feb 22, 2006) School of learning sciences: Design of a multi-user game for learning science students, Philadelphia Area Educational Technology Conference (PAECT), Bryn Mawr, PA
- Shelton, Brett E., Bernotski, Jared, Caswell, Tom, Duncan, S. M., Jensen, Marion, Jorgensen, Jennifer, Scoresby, Jon, Stowell, Tim, The Voices of Spoon River, 1st Edition, http://cle.usu.edu/CLE_IF_VOSR.html, Creative Learning Environments Lab, Winter 2005
- Brooks, Erin & Duncan, S. M. (25 Oct 2003) A Three-Tiered Approach to Simplifying and Standardizing Complex Decisions, AECT Conference
- Duncan, S. M. (23 Oct 2003) Problem-solving in Developing an EPSS, AECT Conference
- Duncan, S. M., Gordon, D. E., & Hu, H. (2001, November 8-12). A posthoc review of two potential communities of practice. Paper presented at the National Convention of the Association for Educational Communications and Technology, Atlanta, GA.

Out of the strain of the Doing,

Into the peace of the Done.

-Julia Louise Woodruff