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# *Creation of reusable open textbooks: Insights from the Connexions repository*

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**Abstract**

Open textbook initiatives have appeared as an alternative to traditional publishing. These initiatives for the production of alternatively copyrighted educational resources provide a way of sharing materials through the Web.

While the open model of peer-produced materials enables the global reuse of textbooks, the combination of fragments to produce new textbooks tailored to particular needs is not easy.

The heterogeneity of topics and target audiences, as well as the cultural and institutional differences of educational systems across the globe, raises the need for new compositional features, fostering—at the same time—the reuse of the newly produced combinations. This paper reviews the current models of reuse and sharing, and presents a quantitative analysis of the Connexions repository which provides evidence about the culture of reuse in open textbook initiatives.

## Introduction

The reuse of learning resources is at the core of learning object technologies. Among other reasons, this is because it is beneficial both from an economic and educational point of view. The ability to reuse other open educational resources (OERs) in the development of textbooks helps offset costs while providing the extra benefit of having more flexible support materials, as the new model allows authors to select and compose new works from the existing works or fragments they find more appropriate. Open textbooks, an affordable and more efficient alternative to traditional textbooks in terms storage, transfer, delivery and accessibility (Lee, Guttenberg & McCrary, 2002), rely on the existence and reuse of OERs to serve their purpose of covering the syllabus in an education program.

The OER philosophy (Kanwar, Uvalić-Trumbić & Butcher, 2011), which rests upon the reusability of learning objects, should not be understood as just another mechanism to cut costs but as a concept with tremendous potential to contribute to improving the quality and effectiveness of education. It should be emphasized that delivering cost-effective, high-quality educational programs and courses implies two fundamental practices:

- *Assembling, adapting and contextualizing existing OERs*. It is essential to make use of, and contribute to, the pool of resources available in OER repositories. Facilitating the adaptation of resources imported from different settings will help build on common intellectual resources, which is more productive than duplicating efforts.

- *Building communities of authors and learners.* The development and repurposing of materials are likely to be more successful and satisfying for the authors if they adopt a team-oriented approach.

The main objective of this research is to provide a quantitative analysis of the Connexions'[1] repository and its community as a prime example of an open textbook platform. This analysis will provide evidence and strategic direction for a culture of reuse, from the point of view of the two fundamental practices cited previously. Therefore, our research question was "to what extent are learning objects really being reused in Connexions?" We did so not because we have a particular interest in Connexions but because we believe that it is a good example from which conclusions can be drawn and extrapolated to other open textbook platforms. To address this issue, the reuse and mixing processes will be analyzed in order to later examine the social networking activity which has emerged from collaboration in the creation of new resources.

Previous efforts have examined the theoretical issues related to the reuse of learning materials (Collis & Strijker, 2004), but there is little literature contrasting these behaviors using real-world data. A first important aspect is that tailoring textbooks is only permitted by certain types of open licenses. Furthermore, repurposing contents in textbooks depends on the availability of the sources. Modularity is the third important ingredient required for repurposing and mixing. As a consequence, the Connections repository was chosen as a pilot for our research due to the fact that it met the following criteria: (1) high quality, modular, personalized on assembly, published on demand content, and (2) site usability (Dholakia, King & Baraniuk, 2006).

Moreover, while the number of contributors and content in Connexions has followed an exponential growth curve, traditional repositories such as Merlot (Malloy & Hanley, 2001) and Ariadne (Duval *et al*, 2001) show a more limited growth potential (Ochoa, 2010), a fact that further increased our interest in Connexions.

*OERs and open licenses*

The term *learning object* was coined by Wayne Hodgins during the early 1990s and later defined as "any digital resource that can be reused to support learning" (Wiley, 2002). In the last 15 years, there have been different attempts to standardize the packaging of learning objects and their metadata in order to facilitate reuse and foster interoperability (Boyle & Cook, 2001; Harman & Koohang, 2007; McClelland, 2003; Verbert & Duval, 2004). A related concept is that of *learning object repositories* (LORs), web portals that make digital collections of learning resources and their metadata available as well as provide web-based search and browsing functionalities.

In 2002, UNESCO convened a group of academics from developing countries to assess a new idea: the OpenCourseWare initiative of the Massachusetts Institute of Technology. The Forum on the Impact of Open Courseware for Higher Education[2] coined the term *open educational resources* (or OERs), namely any type of educational materials in any medium that reside in the public domain and have been released under an open license, permitting access, use, reuse and redistribution by others with no or limited restrictions (Atkins, Brown & Hammond, 2007). OERs are therefore a form of learning objects that is easier to reuse, whose access and reuse potential are improved by using open technical standards.

There are different types of licenses that can be applied to the reuse of OERs. Within the OER movement (Liang, 2004), the Creative Commons[3] (CC)—widely used on the Web (Smith &

[1]http://cnx.org/
[2]http://unesdoc.unesco.org/images/0012/001285/128515e.pdf
[3]http://creativecommons.org/

Casserly, 2006)—is the most commonly used because it is flexible enough to allow authors to express their own philosophy on openness. The four CC license features that users can combine to produce actual CC licenses are provided below:

- *Attribution (cc by)*. Others can distribute, remix, tweak and build upon the original work, even commercially, as long as they credit its creator.
- *NonCommercial (cc by-nc)*. Others can remix, tweak and build upon the original work noncommercially; the derivative works must also acknowledge the original creator.
- *ShareAlike (cc by-sa)*. Others can create remixes and derivative works based on the original, as long as they credit the author and license their new creations under identical terms.
- *NoDerivatives (cc by-nd)*. The creation of derivative works is not permitted.

Examples of commonly used combinations are cc by-nc-sa (attribution noncommercial share alike) and cc by-nc-nd (attribution noncommercial no derivatives).

*Open textbooks initiatives*

The word *textbook* is defined in the Merriam Webster dictionary as "a book used in the study of a subject." Textbooks have been considered a highly adaptable literary genre that has evolved with classroom practice (Wakefield, 1998). Their high cost is a concern, not only for students and their families but also for instructors and educational institutions. e-Books have been proposed as a potential solution (Albanese, 2009; Butler, 2009), and more specifically, open textbooks have been at the core of a new strategy to reduce student's costs (Hilton & Wiley, 2011) by implementing innovative publishing business models. Given that open textbooks organizations and initiatives plan to provide students with their textbooks for free, the traditional source of revenue will need to be redefined. This has raised concerns on the long-term financial sustainability of these initiatives, which in some cases are reliant on donations or volunteering. In other cases, new business models have been devised; Hilton and Wiley (2010) provided background on some of these business models and gave examples of organizations which are currently using them.

Even though nowadays publishers offer e-book alternatives for most of their titles, students still prefer textbooks in their "traditional"—printed—form (Mercieca, 2004; Woody, Daniel & Baker, 2010). In fact, some authors point out the lack of evidence supporting the preference of students for e-books, regardless of their computer use background (McFall, 2005; Woody *et al*, 2010). According to these preferences, open textbook initiatives are increasingly providing the possibility of printing their e-books (eg, through low-cost print-on-demand services). In what follows, only printable open textbooks will be considered, thus excluding from the discussion any other approach such as multimedia or interactive e-books.

Many open texts are available from for-profit publishers such as Lulu,[4] O'Reilly[5] and Textbook Media.[6] Textbook Media uses a "freemium" pricing strategy: some books are given away for free, while premium services are only available at a price (Anderson, 2008). Until November 2012, Flat World open textbooks were available to read for free through the Flat World Knowledge[7] website; this option has since been eliminated: Flat World Knowledge argued financial concerns as the reason for this change. Other open textbooks are stored in repositories that are supported by some combination of government, university and foundation sponsorship. Among these repositories are CK-12,[8] OpenLearn,[9] the California Open Source Textbook Project[10] and Connexions.

[4]http://www.lulu.com/
[5]http://oreilly.com/
[6]http://www.textbookmedia.com/
[7]http://www.flatworldknowledge.com/
[8]http://www.ck12.org/
[9]http://openlearn.open.ac.uk/
[10]http://www.opensourcetext.org/

The latter is somehow different as it offers mechanisms for mixing fragments into textbooks, while the remainder does not do this in a modular way. Finally, some initiatives focus on guiding and adopting contents, such as the Community College Open Textbooks Collaborative,[11] aimed at driving awareness on open textbooks which have already been produced, including peer reviewing and mentoring for teachers (Petrides, Jimes, Middleton-Detzner, Walling & Weiss, 2011). Wikibooks[12] is another example of a noncommercial effort, conceived as a collaborative approach to textbook creation and modeled after Wikipedia.[13] However, the wiki-based model which has made of Wikipedia such a big success doesn't work so well for Wikibooks. Perhaps textbooks "are not quite as susceptible to modularization as an encyclopedia or a newsletter" (Benkler, 2005).

## Connexions overview

Rice University's Connexions is an open-access repository to store learning resources, and it is also a content management system where communities of instructors, authors and learners collaboratively create and share learning materials. The knowledge base is continuously updated—to date, more than 22 000 reusable modules woven into more than 1300 collections—and classified according to tags for a better organization of the resources across disciplines (Baker, Thorstein, Fletcher, Kaur & Emmons, 2010). Two formats are available for developing learning resources: *modules* (small pieces of knowledge usually in the form of a text and with some media associated) and *collections* (groups of modules structured into courses). Connexions departs radically from the traditional notion of a textbook and instead promotes a truly modular design through modules that can be freely organized in collections by a community of users. Indeed, different people (authors) working collaboratively in a structured and reconfigurable manner can create their parts (modules). This in turn allows others to mix the new materials together into new books (course textbooks), while the content management system guarantees that all the parties involved are properly credited for their contributions. In fact, there is an automatic association of an author with the resources he/she has created, which preserves the licensing and moral rights. Reuse policies allow for two different types of reuse: (1) when users *modify* (eg, translate) existing modules and (2) when users *incorporate* existing modules into their collections.

In other words, and following the metaphor of user creation of mixed music collections, Connexions allows users to *create* educational resources, *rip* (adapting them), *mix* (combining them) and finally *burn* them (ie, creating finished printable products). Moreover, it provides its users with editing tools that help authors to publish their materials with the appropriate (open) licenses. Finally, users can (and are encouraged to) collaborate in the construction of modules or collections using content authoring and creation tools (Baraniuk, Burrus, Johnson & Jones, 2004; Henry, Baraniuk & Kelty, 2003).

Connexions can also be used to produce a PDF version of the integrated textbook or module, which can be read off-line, sent to a local printer or sent to Connexions' print-on-demand partner, QOOP. The use of content posted to Connexions in combination with QOOP's print-on-demand technology can produce a printed copy of the textbook at a fraction of the cost of a traditional textbook.

## Methods

In order to classify the data into a number of categories and proceed to calculate their volume, the content analysis methodology (Krippendorff, 1980; Lasswell, Lerner & de Sola Pool, 1952) was deemed as the most appropriate. This research method produces highly reliable (usually quantitative) data which can be easily replicated.

[11]http://www.collegeopentextbooks.org/
[12]http://en.wikibooks.org/wiki/
[13]http://en.wikipedia.org/

The method of quantitative content analysis consists in tabulating the occurrences of *units of analysis* called "content units," grouped into exhaustive and mutually exclusive *categories* (Berelson, 1962). Content analysis aims at statistical formulations directed toward empirical problems. Its statistical significance is one of its most distinctive attributes.

The content units for this case study were Connexions modules, Connexions collections and authors involved in the creation of modules or collections. It is important to define a couple of concepts that will be used in the forthcoming pages:

- *Unique module*. A generic reference to a set of different versions of a resource, irrespective of each particular version. Given that, for instance, three different versions of a module on introductory programming in PHP can coexist in Connexions, we will not treat them as three different resources but instead as only one (hence the name *unique module*).
- *Isolated unique module*. This is a unique module that is not included in any collection.

The *category* of all modules contained in Connexions (this category to be hereinafter denoted by *CNX*) can be partitioned in two disjoint subcategories (Figure 1): one (which we will denote by *IM*) including all isolated unique modules and the other one (which we will denote by *CM*) whose elements are all unique modules included, at least, in one collection. The number of modules belonging to CNX, IM and CM will be represented as *#(CNX)*, *#(IM)* and *#(CM)* respectively.

Data from a total of 20 401 modules and 1186 collections were encoded (January 2012) with the help of a computer program (crawler) (Weber, 1985), which systematically traversed the pages in Connexions. We examined the metadata of the resources in Connexions to go into more detail later on each type of resource, dataset and reuse strategy.

However, before proceeding, let us take a few lines to examine the meaning of *reuse* as our method relies, and is based on, the different approaches to the term. The word *reuse* considered as an operation or action feasible to be performed on an object recurs in almost all conceptualizations of learning objects (Wiley, 2002); however, it is often poorly understood because it can describe several different types of use (Downes, 2007). According to McMartin (2008), *open resource* means that the resource is available to others for being *used (reused)* in different contexts. Thus, we departed from the four "Rs" of openness identified by Wiley (2009):

- *Reuse*: to use all or part of an existing work for new purposes;
- *Redistribute*: to share a work with others;
- *Revise*: to adapt, modify, translate or change the form of a work;
- Remix: to take two or more existing resources and combine them to create a new resource.

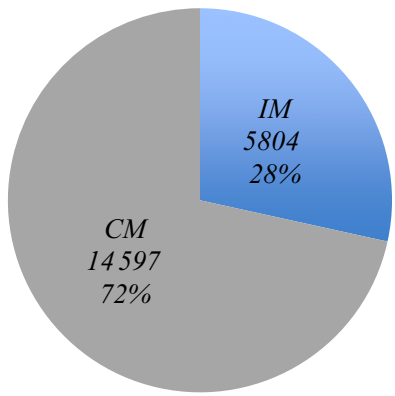



*Figure 1: Conceptual model of Connexions modules (CNX): IM and CM components. ■, IM; ■, CM*

Contrary to what Wiley stated, the term *reuse* is commonly understood in most communities of teachers, learners and authors as "reusing existing resources even if there is a need for modifications in the original work." Therefore, we will assume, in the context of Connexions and for this research only, that the terms *reuse* and *revise* are synonyms (even if they are not, according to Wiley's point in the four Rs). Their meaning will thus be, in the context of Connexions and only within the scope of this research, the actions allowed on a re-used resource, including adapting, modifying, translating or changing its original form. So, in what follows, they will be used interchangeably. Apart from this, *remix* (or simply *mix)* shall be considered as the act of combining two or more existing resources into a new one (thus giving attribution to the original resources).

The derivative functionality supported by Connexions was the first target of our study: revise. In Connexions, this is the case of modules that are translated into other languages, although not all the derivative works are translations: modules are modified for a number of purposes. It is important to note that the identifiers of the derivative and the original modules are different; moreover, derivatives have to include the module id of their originating module. The collections in the repository (remix) and the collaborative features (collaborative authoring) are the other two aspects in this reuse-and-mix culture that we analyzed.

Unlike other studies published on the topic (Duncan, 2009), the present research involves analysis of all areas of knowledge contained in Connexions (ie, the modules not included in any collection were also analyzed).

## Results and discussion

*Derivative modules (revise)*

An important part of the value of the Connexions repository is the ease of creating derivatives of existing modules. Therefore, we will examine the situation of isolated modules and will analyze how these are being reused. The total count of isolated unique modules was 5804 (ie, $\#(IM) = 5804$). Taking in account that $\#(CM) = 14\,597$, the total count of Connexions unique modules published was 20 401. In other words, this means that about 28% of modules published in the Connexions repository are isolated knowledge chunks not integrated into larger content structures. Although the degree to which the modules were combined into collections is discussed later, a first conclusion is immediate: *almost a third of all modules in the repository were not combined (remixed) within collections.*

As previously said, an important feature in Connexions is the facility for creating derivatives from modules. Out of a total of 5804 isolated unique modules, 163 were derived modules. These figures indicate that just 2.8% of the total isolated unique modules were derivative copies of other modules. As shown in Figure 2, out of the 163 derived modules, 55 of them (34%) were derivatives of another isolated unique module. In contrast, the remaining 108 (66%) modules were derivative copies of modules included in collections (CM). This means that, in the set containing the modules not included in any collection (IM), the derived modules were based twice as often on modules included in collections (modules in CM) than on other isolated modules (other modules in IM).

Figure 3 shows that out of the 14 597 unique modules in the CM set, 555 were derived modules. That is to say 3.8% of the resources in CM were derivative copies of other modules, a percentage similar to that of the IM set (isolated unique modules). The bar sections with lines represent the derived module count in IM (163) and CM (555) respectively. Among these derived modules, the bar sections with dots show the number of IM modules (55) and CM modules (508), such that their originating modules belong to the same subset, namely, IM and CM respectively.

It is interesting to note that all the originating modules generating derivatives in CM belong to CM.

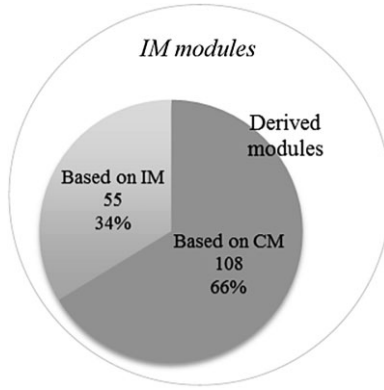



*Figure 2: Subset of derived modules in IM*

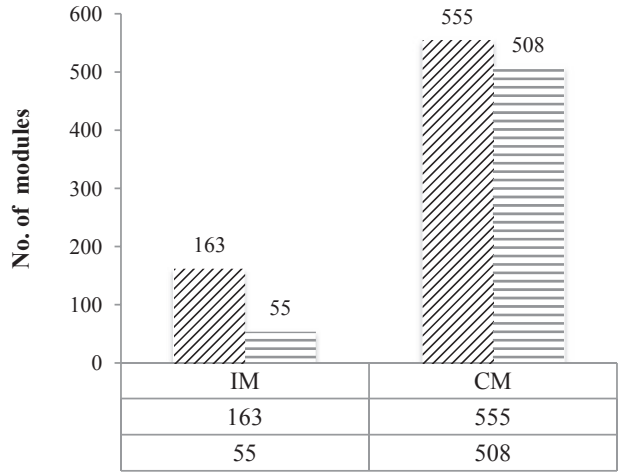



*Figure 3: Derivative modules in Connexions repository. ⁄, derivative modules; =, originating modules*

*Table 1: Derivative modules in CM with different adaptation types*

| *Derivative module* | *Originating module* | *Adaptation type* |
|---|---|---|
| ID: *m17325*<br>Title: *Sampling and Data: More on Sampling* (edited: Teegarden)<br>Included in collection: *c10561*<br>Collection title: *Collaborative Statistics* (with edits: Teegarden) | ID: *m16018*<br>Title: *Sampling and Data: More on Sampling* | Modification |
| ID: *m12863*<br>Title: *Conceptos Básicos de Vectores*<br>Included in collection: *c10373*<br>Collection title: *Señales y Sistemas* | ID: *m10844*<br>Title: *Vector Basics* | Translation |

Examples corresponding to derivative copies of modules which were elements of CM (ie, modules included in some collection) are shown in Table 1. For each derivative, the third column indicates the adaptation (*revision*) applied to the module used to generate it: translation or modification.

*Table 2: Summary of derivative work in Connexions*

| *Module type* | *Total count* | *Originating modules* | *Derivative modules* | *Reuse rate* | *Percentage (%)* |
|---|---|---|---|---|---|
| IM | 5804 | 47 | 55 | 1.17 | 0.8 |
| CM | 14 597 | 438 | 508 | 1.16 | 3 |
| CNX | 20 401 | 575 | 718 | 1.24 | 2.8 |

As can be seen in Table 2, 47 isolated unique modules (IM)—out of a total of 5804—were translated or modified into 55 derivatives (ie, the count of how many times an individual module in IM is revised [the total reuse count in IM] was 47 times). These calculations carried out in IM led us to obtain a reuse rate of 1.17 (each module was reused an average of 1.17 times), resulting in 0.8% of the cardinality of the total IM set.

Considering only the data extracted from CM, 438 out of the 14 597 (3%) CM unique modules were translated or modified into 508 derivatives, getting a reuse rate of 1.16 times for each reused module.

The first two rows in Table 2 show information corresponding only to modules of the same type (ie, the derivatives and their originating modules are elements of the same partition [IM or CM]); therefore, the results are valid within those boundaries. Data appearing in the third row take into account all modules included in the Connexions repository (CNX). Reuse rates are close to 1 and reveal a constant behavior. On the other hand, the percentage of reused modules is of little significance. Two straightforward conclusions can be derived:

- The lack of reuse (revise) is significant across the entire CNX repository.
- When reusability occurs, it is only to a small extent.

While there was only one isolated module of the Ethics Across the Curriculum (EAC) series, *m14291 EAC Toolkit: Student module template*, which was the most reused (18 times), almost every other was revised less than four times; moreover, 480 modules were revised only once.

*Collections (remix)*

In this section, we will analyze quantitative data on remix (ie, the composition of collections combining modules). The first calculations were the result of counting how many times modules were included in any collection, which was 18 855 times, and the total count of unique modules that were included just in one collection, which was 11 963 modules. Bearing in mind that *#(CM)* = 14 597, it becomes evident that 2634 modules were included more than once in collections contained in the Connexions repository.

In order to provide insight about the frequency of reuse (ie, using a module as is by including it in one or more collections), two components were considered: reuse percentage frequency (RPF) and reuse rate frequency (RRF). The RPF component allows us to quantitatively compare the "reused" modules with respect to the "used" modules in collections:

$$\text{RPF} = [\text{total count of modules "used" more than once}/\#(\text{CM})] \times 100.$$

In this case, the RPF value was 18.04%.

As for RRF, this is a component that allows to quantitatively compare how many times an initial use of the module is exceeded with respect to the total count of modules that were included more than once in a collection:

$$\text{RRF} = [\text{number of times that modules were included in any collection} - \#(\text{CM})]/(\text{total count of modules "used" more than once}).$$

*Table 3: Number of modules contained in N collections*

| Modules | 11.963 | 2.090 | 229 | 104 | 59 | 18 | 30 | 27 | 25 | 27 | 16 | 8 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *N* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |

*Table 4: Statistical measures*

| *Measure* | *Number of modules* |
|---|---|
| Mean | 15.8 |
| Mode | 6 |
| First quartile | 6 |
| Midquartile (median) | 14 |
| Third quartile | 45 |

In our case, RRF was 1.61, which indicates that the RRF is 1.61 times for each module included more than once in a collection.

Summing up, these two metrics show that 18.04% of the CM modules were included more than once in collections, with an RRF of 1.61 times for each module reused (remixed) more than once.

Table 3 shows the total number of modules included in $N$ ($N = 1 \ldots 13$) collections of the Connexions repository. Just as an example, it should be mentioned that the module *m16310*: *Descriptive Statistics: Summary of Formulas* was the most used (it was included in 13 collections).

In order to achieve conclusions from a reciprocal point of view, a dataset was set up including information for each instance of a collection. This dataset included the number of unique modules in the collection, some common measures of central tendency (arithmetic mean, median and mode) and also measures of relative standing (percentiles) of this distribution of data.

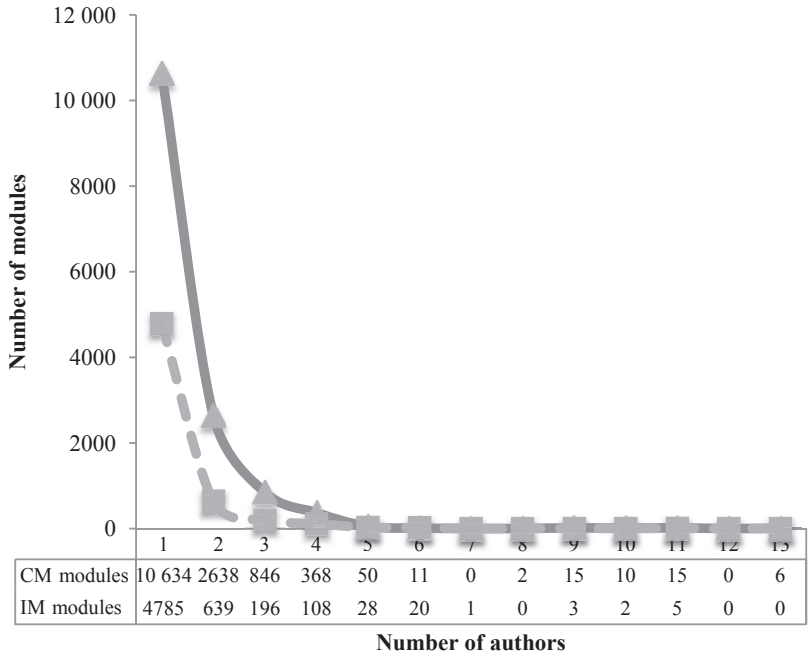
The traditional statistical measurements in Table 4 show that the following:

- The number of modules included in any collection that occurs most often is six. There were 72 collections that included each of them six unique modules.
- Twenty-five percent of the total count of collections (≈296) contains (each one) at most six unique modules (ie, 75% of the collections contain at least six modules).
- Fifty percent of the total count of collections (≈592) contains each at most 14 modules.
- Seventy-five percent of the total count of collections (≈890) contains at most 45 unique modules.

*Authorship (collaboration)*

This section shows, from a social network point of view, the collaboration activities inside Connexions. Calculations were carried out so as to measure the extent of collaboration in the same module as well as to analyze the relationship between authors involved in the creation of a module and its containing collection.

Figure 4 shows the number of authors per module. The term "author" in this context is considered to include all the authors of the learning object, irrespective of their particular order or type of contribution. The results reveal that in the case of isolated unique modules (IM), virtually 82.4% (4785 modules) have a single author. We found similar results for CM modules (72.9%, from a total of 10 634 modules). Another interesting result is the remarkable 3.3% (479 modules) that have four or more authors.




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CM modules | 10 634 | 2638 | 846 | 368 | 50 | 11 | 0 | 2 | 15 | 10 | 15 | 0 | 6 |
| IM modules | 4785 | 639 | 196 | 108 | 28 | 20 | 1 | 0 | 3 | 2 | 5 | 0 | 0 |

*Figure 4: Number of authors per module. —●—, CM modules; - -■- -, IM modules*

Figure 4 leads to the following conclusions:

- A significant amount of working groups is comprised of only one author.
- Modules included in at least one collection which also had a single author were four times more frequent than those credited to two. In the case of isolated modules, this frequency was up to seven times greater.
- The degree/extent of collaboration among authors in the same module is quite low. Interestingly enough, the set of modules (IM) not integrated into larger portions of knowledge shows this feature more clearly. Therefore, IM elements contained modules with a lesser degree of collaboration from a social point of view.

For each instance of a unique module used in a collection, the number of common authors was considered. From the 14 597 resources in CM, 9876 had common authors. The same happened with 796 resources out of the 1186 collections. This means that

- A high percentage (67%) of the collections in the repository include modules whose author is also the creator of the collection.
- Modules were included in collections twice as often when both—module and collection—had at least one author in common.

## Conclusions and outlook

Current models of reuse and share in open textbook initiatives have been reviewed. The case of Connexions, a repository providing explicit support for composition of collections from modules as an effective mechanism for mixing, has served as a case study. This pilot case study was conducted to analyze the processes of reuse and remix; later, the social networking activity emerging from the collaboration to create materials was examined.

In this research, three dimensions (categories) were taken in account: two *object dimensions*, concerning physical objects contained in the repository (modules and collections) associated to revise and remix features, and a third *social dimension*, concerning human individuals (authors).

The results showed that the lack of reuse is significant across the entire repository CNX (Connexions), and when reusability occurs, it is only up to a small extent.

In the same way that modern research is usually a team effort, the development and repurposing of materials are likely to be more successful and more satisfying for the academic staff involved if a collaborative writing approach is adopted (Horner & Blyth, 2008; Posner & Baecker, 1993). However, the explorations carried out in this research (see Authorship section) illustrate that most authors of collections only use modules written and developed by them (over 65% of the collections include modules whose author is also the creator of the collection, while modules included in at least one collection which also had a single author were four times more frequent than those credited to two authors). The results demonstrate a very low degree of collaborative authoring in Connexions. This lack of collaborative writing activities might hinder the success in promoting resource reusability.

The sustainability of OERs is greatly influenced by the approach employed for reusing and mixing existing resources (or parts thereof) as technical platforms require the adoption of open textbook initiatives. The results show that in Connexions, the relationship between an author's reuse of their own as opposed to other's learning objects is quite extensive; therefore, the object dimensions are strongly dependent on the social dimension. While the results are indicative, the pilot study suggests important implications for open textbook initiatives.

In this context, the development of social networks and communities of practice in the repository could provide a suggestion on how to conduct future research on LORs' reusability to overcome the abovementioned shortcomings. This research would validate whether authors can benefit from using existing online networks and communities of practice to collaboratively develop, adapt and share OERs.

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