Library resources and students' learning outcomes: Do all resources have the same impact on learning?

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This article investigates the relationship between the use of library resources and learning outcomes in a Chilean research-centered university by analyzing data from two consecutives semesters of student records, library borrowing, and access to electronic resources through the library. Results show that the access to electronic resources has a greater impact upon performance than the number of library items borrowed. They also show that an increase in the number of sessions dedicated to accessing electronic resources was accompanied by a decrease in the number of library items borrowed as students progress in their degrees. Further analyses showed that students' behavior is attributed more to the requirements of advanced courses (commonly encountered in later years of their degrees) than to personal preferences. This relationship between student records and library services enlightens the impact of different library resources on student learning and offers evidence to rationalize library investments according to their needs and impacts.

Keywords: Library, Library Resources, Electronic Resources, Student performance, Learning Analytics

Introduction

Libraries play a key role in the university student experience. They embody core values of scholarship as repositories of knowledge (Kuh & Gonyea, 2003). They gather the products of scholarly work for public access and offer physical space where students can meet for academic work, working collaboratively and broadening their intellectual horizons (Soria, 2013). With the emergence of digital technology, libraries have

advanced towards increasing provision of electronic resources such as e-books, online catalogues, reference management systems, online bibliographic databases and online journals. These resources make access to knowledge and information easier, deepen possibilities for being in touch with up-to-date and high quality materials, enhance bibliographic research, and provide tools for creating and updating personal collections of bibliographic material (see for example, Knight, 2013; McLaughlin, 2011; Taha, 2012). Nowadays, libraries provide an experience that intertwines the physical and the digital, which is in turn embedded in the broader ecology of student learning, and encompasses classrooms, learning management systems, professors, other students, and so on (Ellis & Goodyear, 2010).

In a context of competing demands for limited funding and growing student expectations, university services and programs are often required to demonstrate evidence of their effectiveness. This compels libraries to progressively demonstrate their value in more concrete terms than simply pointing to their clear academic value (Stone & Ramsden, 2013). Research on student use of library resources and library impact on academic achievement has emerged in response to this trend. Usually, librarians assess library services value by gathering students' experiences through surveys or focus groups. Some library managers and scholars question these methods because they rely mostly on self-reports and, as such, they provide only indirect measures of impact, giving a snapshot relevant only to the timing of the study. Besides, they are, especially in the case of surveys truly representative of the population, costly exercises (Cox & Jantti, 2012). Proposing a different approach, a report from the Association of College and Research Libraries (Oakleaf, 2010) posits that researchers have made little use of the data that can be obtained directly from their own institutions information systems. Students' interactions with library services and resources, both

physical and digital, create large repositories of data, which are a rich potential source for understanding how students access library resources. Appropriate matching of these data with students' academic information can lead to a more complete picture of how students use the library (in the context of their degree) and how this is associated with academic achievement. The report emphasizes that this kind of study is the way forward toward a more authentic assessment of the value of library services.

This call for a closer look at how students use the library connects the field of library research with the emergent fields of learning analytics (LA; (Chatti, Dyckhoff, Schroeder, & Thüs, 2012; Siemens & Long, 2011) and educational data mining (EDM; (Romero & Ventura, 2013). These two research areas are focused on analyzing and making sense of the vast amounts of data originated from educational environments, with the aim of improving teaching and learning. They are emergent research fields in Higher Education, mainly aimed at the detection and characterization of data patterns from large sets of data, such as the ones created by students in their interaction with library services (Romero, Ventura & Garcia, 2008).

Some researchers follow Oakleaf's direction (2010) and have started to use data from their universities information systems – in some cases in conjunction with traditional social sciences research methods – to explore how students' use of library services is associated with their academic outcomes. Initial results from these studies show positive associations between library use and student attainment (see for example, Cox & Jantti, 2012; Goodall & Pattern, 2011; Stone & Ramsden, 2013; Wong & Webb, 2011). For example, Stone & Ramsden (2013) conducted a study on eight universities from the United Kingdom where each university's data was analyzed both independently and together as a whole. They found positive associations between academic achievement and book borrowing, a similar relationship with e-resources

access, but a lack of association with library building access. Through the analysis of focus group data, the authors also found that students have a very positive attitude toward library services: they perceive a positive association between their academic attainment and their library use; they value library resources despite of the available on-line resources; they perceive that library space is for learning, using technology and meeting work mates; and, they value library personnel support. Similarly, Goodall & Pattern (2011) found that, despite university students' low rates of library services access (at least 50% of them never borrow a book), there are positive correlations between library use and their class mark. In general students with higher marks use the library more than those with lower marks. At the same time, when considering visits to the library, results show that in some universities students with lower marks tend to go to the library as much, or even more, than those with higher marks. In addition, Cox & Jantti (2013) found a very strong non-linear relation between use of e-resources and average marks by access amount ($R^2 = 0.87$), which increased if extremely poor performers were left out. Moreover, nonlinear correlation between borrowing books and average mark was also strong ($R^2 = 0.73$), although a bit less than for electronic resources. Finally, Wong & Webb (2011) found that for 5 out of 7 major academic units at their university (Academy of Visual Arts, Faculty of Social Sciences, Faculty of Arts, School of Communication, and Faculty of Science) there was a significant correlation between average mark and use of library resources. Studies such as these are in line with the purpose of providing libraries with evidence to demonstrate their value and, at the same time, adjust resources to better meet users' needs (Plum, Franklin, Kyrillidou, Roebuck, & Davis, 2010).

When observing the data, there are usage patterns that differ from one institution to other that require a further exploration in order to make the evidence base stronger

(for example, low use of e-resources in England and high use in Australia). The present article expands this issue by introducing the outcomes of a study on possible relationships between students use of library services and learning outcomes, conducted in one Chilean research-oriented university.

In this study we focus on the relationship between physical and digital library resources and student performance. Our research questions are:

1. Is there any relationship between uses of electronic resources, access to physical library resources and students' performance?
2. Is there a change in the pattern of use of electronic and physical library resources in students at different points in their university education?

To answer these questions, we first do a descriptive and correlational analysis of the data obtained from student records, library borrowing, and electronic resources databases. We take into account all students enrolled in two consecutive semesters at the research-centered university involved in this study without making any distinction by degree or enrollment year. For the second question, we do an in-depth descriptive and correlational study for the same time period, taking into account the discipline to which the student belongs and their enrollment year.

Methodology

This project had access to three databases: library loans (ALEPH), electronic resources access (EZPROXY) and student academic information (DARA). **Table 1** shows a general description of each database. All the data correspond to two consecutive semesters at the university, the second semester of 2012 and the first semester of 2013.

Table 1 *Description of the databases used in this study*. We had access to the students' personal records, students' borrowing records, and log files from the authentication server for the electronic resources access.

Database	Description	Data obtained	Approximate number of records per semester
DARA	Students' personal information and marks of student	Student demographics, career and courses marks	120.000
EZPROXY	Authenticated access to Electronic Resources	Connection time, number of sessions, actions	6.000.000
ALEPH	Students' borrowing records	Number of items borrowed, types of items borrowed, length	600.000

The DARA database is the main university database for students' academic and socio-economical information and it is composed of several relational tables. The university assigns a unique number to each student-degree combination, so students that are enrolled in more than one degree during their time at university have more than number. They can however be linked by their national identity number and the university assigned email. From the database table descriptions, we selected the fields that were relevant for the study: enrollment year, course marks by semester to indicate performance, degree, university school (department), national test scores (university entrance exams) to control for previous knowledge, school dependency (public, private or charter) as a proxy for student socio- economic background, gender national identity number, and university assigned email. In order to be able to identify users across databases while protecting students' identity, we applied hashing to the national identity number and the university assigned email to create a unique code that was used for indexing across databases.

The ALEPH database was simpler; we were interested in one out of three tables. The database has detailed information about the date and time the items were borrowed, as well as a classification of borrowed material in twenty different categories, from printed books to study rooms. For this study, we created a summary of students' borrowing by grouping them into three categories: Print Material, Audiovisual Material

and Physical Space. These three categories account for the 95% of all the borrowed library resources.

The EZPROXY is a proxy server that mediates all students' requests to electronic journals and bibliographic databases to which the university has access; we will identify these as Electronic Resources. Its log file is a text file where each line is an instruction sent through the service together with identification information like user name (the university email), IP address, domain, and time, among other information. We associated every line as an action triggered by the user's search. Only users that access the service from outside of the university network are requested to authenticate using their user name, therefore not all of the actions in the log file can be associated to a student. However, an analysis using the IP address of the logged actions showed that in average 76.9% of the connections were authenticated, a total of 6,220,960 actions, assuring us that the set of actions that can be associated to a user conforms is a representative sample of the log file.

Some of the actions triggered by the user query were actions for type-ahead search techniques and redirections, as is typical of site search engines. Therefore, to measure the student's use of this resource without counting these automatic procedures, we calculated two variables from the available information. One variable, called Electronic Resources Activity, counts the number of time segments of 10 minutes long where the student had at least one action (a line in the log). The other variable is called Electronic Resources Sessions and it corresponds to the length of the time interval in which a user has several consecutive actions in the same domain, commencing with the first action and continuing until the last action, with a difference not greater than one hour between actions. We created scripts that filtered relevant information from the text

file and built a database for the EZPROXY activity that was indexed by the study unique code for the protection of anonymity.

Marks are highly correlated with the degree in which students are enrolled, since each of them sets different for minimal performance. Due to this fact, we calculated a standardized mark for each degree to have a common mark scale across them. Through this procedure, all students that have a standardized mark of 0, no matter to which degree program they belong or to what course they attend, lay at the fiftieth percentile of their group, whereas those with a standardized mark of -1 or 1, lay at the 16^{th} and 84^{th} percentile, respectively. Since a student is enrolled in several courses each semester, we measured each student's overall performance per semester by calculating the Standardized Semester Average Mark for each student by averaging the standardized marks across their courses for that semester. The advantage of this procedure is that when we apply regression analysis in order to measure the effect of the library resources on the marks, the effect of previous knowledge is reduced drastically; therefore, we are able to obtain a reliable value for the size effect of the library resources.

Results

Our first analysis showed that the number of students that accessed each resource differ significantly. Only 20.6% of students accessed an electronic resource at least once (a value of Electronic Resource Activity different from zero), whereas 67.8% of students had borrowed at least one item across the time period of the study; 11.9% borrowed at least one Audiovisual Material; and 22.2% reserved at least once a Physical Space inside the library. Table 2 compares the mean of the Standardized Semester Average Mark for students who do not use any library resources (Not Used) to those that use library resources (Used). The table shows the mean for each group, its standard error

(SE), and the 95% confidence interval (95% CI). The last row presents the Cohen's *d* size effect measure of every resource over the Standardized Semester Average Mark.

Table 2 ***Standardized Semester average mark given resources' use.*** Mean, standard error (SE) and 95% confidence interval (95% CI) for the Standardized Semester Average Mark of students that do not use a library resource (Not Used) and those that use it (Used). The last column indicates the size of the effect by giving Cohen´s d. The symbol * indicates those figures whose differences are significant at the 0.05 level.

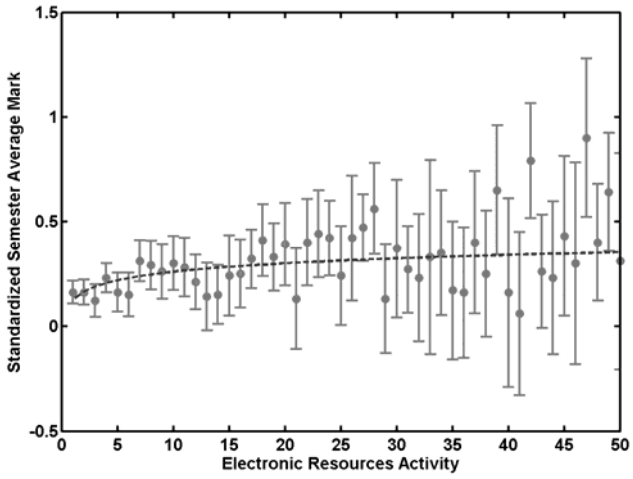
	Standardized Semester Average Mark								
	Not Used				**Used**				
Resource	**Mean**	**SE**	**95% CI**		**Mean**	**SE**	**95% CI**		**Cohen's d**
Electronic Resources*	-0.07	0.006	-0.08	-0.05	0.25	0.010	0.23	0.27	0.324
Print Materials*	-0.05	0.010	-0.07	-0.04	0.03	0.006	0.01	0.04	0.080
Audiovisual Materials	0.001	0.005	-0.01	0.01	-0.01	0.014	-0.04	0.02	0.008
Physical Spaces	0.004	0.006	-0.01	0.02	-0.01	0.010	-0.03	0.01	0.017

*: differences significant at the 0.05 level

The only resources whose use have a significant effect are Electronic Resources (*t-test*, F=39.37, p<.01) and Print Material (*t-test*, F=87.43, p<.001). Electronic Resources have a medium Cohen's *d* of 0.324, whereas Print Material have a small one of 0.080. This reveals the greater effect that Electronic Resources have on students' performance. The table shows that students that access Electronic Resources or borrow Printed Materials in a given semester have a statistically higher semester average mark than those who do not use those resources. This result is corroborated when we calculate the correlations among the Standardized Semester Average Mark and Electronic Resources Activity, number of Print Material borrowed, number of Audiovisual Material borrowed and number of Physical Space reservations. The only significant correlations occur with Electronic Resources (r=.084, p=.01, two tailed) and Print Material (r=.043, p=.01, two tailed), showing that students with high average scores are more likely to access Electronic Resources than to borrow Print Material, and show no preferences at all for the other type of materials.

Figure 1 represents the relationship between student performance and access to electronic resources. In this figure, the dots with error bars represent the mean of the Standardized Semester Average Mark for all the students with the same amount of Electronic Resources Activity. They are plotted against the amount of Electronic Resources Activity to illustrate how the students' performance is correlated with the number of times that they access the Electronic Resources. The line represents a logarithmic regression for the data (R^2=0.387, F(1,718)=4528.37, p<.01). As we see from the figure, a large Electronic Resources Activity correlates nonlinearly with a large Standardized Semester Average Mark.

Figure 1 *Mean of the Standardized Average Score for students with a given Electronic Resource activity in function of the Electronic Resources activity.*



Finally, we perform a stepwise linear regression of student performance for each semester' in function of the use of every available library resource to measure the predictive power that each resource has on students' performance. The stepwise approach consists of building more complex models by adding one variable at a time. This approach allows us to determine the change in predictive power of each variable as other variables are added.

Table 3 shows the results of our stepwise linear regression of the Standardized Semester Average Mark as dependent variable in function of the logarithm of the Electronic Resources Activity, the number of Audiovisual Material borrowed, and the number of Print Material borrowed. The Selection Exam Average Score was introduced as a control variable for previous knowledge (the Selection Exam is a mandatory national test that Chilean students need for applying to all major universities in the country).

Table 3. Stepwise linear regression of Standardized Semester Average Mark as a dependent variable in function of logarithm of Electronic Resources Activity, Audiovisual Material items borrowed, Print Materials items borrowed, and Selection Exam Average Score.

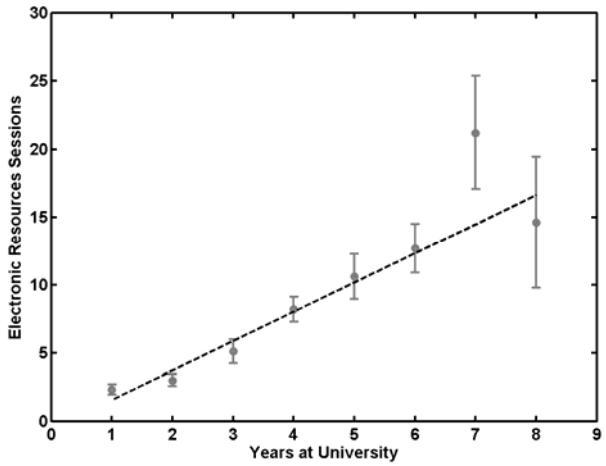
	B	**Std. Error**	**Beta**
Model 1			
log(Electronic Resources Activity)	0.198	0.018	0.130**
Model 2			
log(Electronic Resources Activity)	0.175	0.018	0.115**
Selection Exam Average Score	0.001	0.000	0.068**
Model 3			
log(Electronic Resources Activity)	0.175	0.018	0.115**
Selection Exam Average Score	0.001	0.000	0.067**
Audiovisual Material	-0.003	0.001	-0.030*
Model 4			
log(Electronic Resources Activity)	0.177	0.018	0.116**
Selection Exam Average Score	0.001	0.000	0.070**
Audiovisual Material	-0.004	0.001	-0.035**
Print Material	0.001	0.000	0.024**

Model 1: R^2*=0.017, DR=0.017; Model 2:* R^2*=0.021, DR=0,004; Model 3:* R^2*=0.022, DR=0.001; Model 4:* R^2*=0.022, DR=0.000 **: p>0.05; *: p>0.10*

The variable that had the largest effect on student performance (Standardized Average Course Score) is the logarithm of the Electronic Resources Activity in all four models, with a standardized coefficient *beta* ranging from 0.130 to 0.115, followed by Selection Exam Average Score with *betas* ranging from 0.067 to 0.070. The number of Audiovisual and Print Materials borrowed provide little explanation of students' performance, even though the relationship between performance and Audiovisual Materials is negative. The explained variance R^2 of 0.020 is small for all models, which may due to the large number of factors that can explain student performance and that are not included in this study. Yet all the relationships are significant at the 0.05 level. The best model in accordance with the Akaike Information Criterion (AIC; Bozdogan, 1987) is model 4, where all the variables are included. As we see from the previous results, they are consistent and indicate that the use of Electronic Resources is largely correlated with student performance: students that have a large Electronic Resources Activity have better marks, even controlling for previous knowledge.

Our second research question seeks to uncover any change on the pattern of use of Electronic Resources and Print Materials as the students advance in their degrees. Figure 2 shows the average number of Electronic Resources Sessions for students that have spent the same number of years at the university in function of the number of years that they have spent.

Figure 2 Average Electronic Resources Sessions for students that have spent the same quantity of years at university in function of the number year that they have spent.

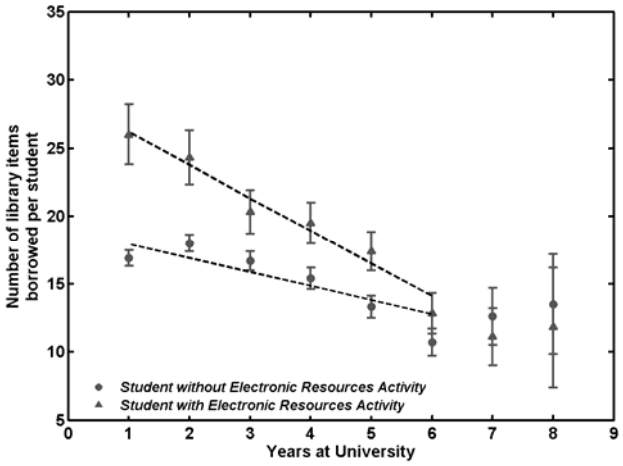


The graph shows how the pattern of use of Electronic Resources depends on the number of years that students have spent at the university. As students advance in their degrees, the number of sessions to access Electronic Resources increases steadily, showing a little drop at the eighth year. This drop can be explained by taking into account that the longest degree in the university lasts seven years (Medicine), and the number of students that stay longer reduces drastically. The line in Figure 2 represents a linear regression for the first six years (R^2=0.967, F(1,37002)=1084626.14, p<.001), where the data behavior is quite linear. It shows the increase in the number of sessions across years. The number of sessions increases at a pace of approximately 2 sessions by year (B=2.152, $BETA$=0.983, p<.001) reaching a maximum of 16 sessions by year six. This increase in the number of sessions used for accessing Electronic Resources can be explained by taking into account that as students advance in their degrees, more specialized and updated knowledge is required and this knowledge is mainly present in journals and online material that are scattered around the databases. Therefore, more advanced courses require that students look for material that is readily accessible as Electronic Resources. As a consequence of this behavior, it may be expected that the

number of Library items borrowed should decrease as students advance in their degrees because the low availability of advanced study material at the Library.

Figure 3 shows how the number of library items borrowed per student, including Print Material, Audiovisual Material and Physical Space, evolves as students advance in their studies. These quantities were obtained by adding up all the items that students with the same amount of years at the university have borrowed across the semester and averaging for the sample. In the figure, we compare the trend across years for students that have any Electronic Resources Activity and for those students that do not have any Electronic Resources Activity.

Figure 3 Average number of library items borrowed (Print, Audiovisual and Physical Space) per student in function of the number of years at university for students that have any Electronic Resources Activity and those that do not.



For both groups there is a steady decrease in the number of items borrowed as they advance in their degree, with a minor increase after the sixth year. This change in behavior can potentially be attributed to students extending their time at university to meet graduation requirements, for example, in degrees that require writing a dissertation. However, the group of students with Electronic Resource Activity, i.e. that have accessed Electronic Resources along the semester have, on average, a larger number of items borrowed in comparison with the groups of students that have not accessed them, at least until year six of their studies. This difference in behavior

challenges the affirmation that our students, digital natives, are more prone to digital material and decreasing interest in printed material. In fact, our graphs show that students who access Electronic Resources also borrow more Library material, especially Print Material, compared to those students who do not access the Electronic Resources. This behavior complements, and partly explains, our previous results showing that students who access Electronic Resources are more likely to have higher average marks than those who do not; they may tend to be more strategic and involved in their learning.

The lines in Figure 3 show a linear regression for the data until year six for both groups (students with Electronic Resources Activity: R^2=0.96, F(1,7368)=175342.19, p<.001; students without Electronic Resources Activity: R^2=0.71, F(1,29632)=73973.98, p<.001), showing that students with Electronic Resources Activity have a steeper drop in their number of items borrowed across years. Although the decrease in the number of items borrowed for students with Electronic Resources (*B*=-2.17, *BETA*=-0.98, p<.001) doubles those who do not have any activity (*B*=-1.03, *BETA*=-0.85, p<.001), students with activity start with a larger number of items borrowed (constant=28.9, p<.01, versus constant=18.97, p<.001) and, by year six, both groups have a similar number of items borrowed. This result shows that the access to Electronic Resources is complementary to borrowing Print Materials in the sense that students who are prone to using Electronic Resources are more likely to borrow Print Material; in fact, our study shows that both resources are more likely to be used by students with higher marks, despite the fact that Electronic Resources have a bigger effect on student performance.

Discussion

Our first analysis showed that the number of students that access each library resource differs significantly, suggesting that the preferences for the different types of resources depends upon personal or cultural factors. Although the overall use of library resources for this university is more than the one in Goodall & Pattern's study (2011), the impact that each resource has is different. We found that access to Electronic Resources, (e.g. electronic journals and online databases) have a bigger effect on students' mark than borrowing Print Material (e.g. books, printed journals or thesis); whereas borrowing Audiovisual Materials or Physical Spaces have no effect whatsoever.

Our results about library service access coincide with those found by Goodall & Pattern's study (2011), although we are able to provide results with a more fine-grained distinction between the different type of services. One interesting finding is that, although study rooms (Physical Spaces) are perceived as a worthy library service, where students can meet with fellow students for learning and technology use, our study showed that this service has no effect on marks. While this does not imply that such rooms have no value to students, it does open the question to further research into the kinds of value that such rooms do have, e.g. developing social capital of students. This discrepancy between student perceptions and data results can be used as evidence against the indiscriminate use of surveys and focus groups to determine the value of library services. However, the amount of data that we have is not sufficiently substantial to be able to generalize to other contexts (e.g. different libraries/universities and different countries/continents). In fact, only 22.2% of the university students used a Physical Space, and in the process only one student of the group is recorded as the borrower. Therefore, we do not have any information about the rest of the students that participate in the group study session, representing a limitation of this study. But what it is clear, confirms the results from Cox & Jantti (2013), is that the use of Electronic

Resources has a stronger effect on the Standardized Average Semester mark. Our results showed that, if we compare scores between people that do and do not use electronic resources, the students that use electronic resources are more likely to have better marks in their semester courses than those who do not. As we analyzed the effect of Electronic Resources Activity on the Average Semester Standardized Mark, controlling for previous knowledge, we can assume that the effect found can be associated mainly with the Electronic Resources Activity and not to student capabilities. We are not simply showing that good students are more prone to use electronic resources, but rather that the use of electronic resources does have an impact on students' marks.

Another result from our study is the change of pattern of student use of library services during their degree. First, we found that, as the students advance in their degrees, the use of Printed Material decreases whereas the number of sessions for accessing Electronic Resources increases. This inverse pattern may provide insights into the changing nature of the classes that students encounter across their academic/university life. One possible explanation of this result is that at the beginning, most of the general subjects related to the degree, even those that belong to other disciplines, are presented. Students might strategically use more textbooks, which are not necessarily up to date in terms of content knowledge, but can help them in their studies. As students advance in their degrees, more specific content knowledge is required and the need for more current and specific information increases, compelling the students to access more electronic journals and online databases. This pattern may be more strongly present in the final year of a degree, where a dissertation work or an internship requires more current information. However, we agree with Stone & Ramsden (2013) that the use of Electronic Resources is not in competition with borrowing Printed Materials. Our results show that students who use Electronic

Resources are more prone to use Print Materials than those who do not access at all Electronic Resources, and that, although both groups decrease in their number of items borrowed across the years, they reach an equal number of items borrowed at the end of their degrees. This result suggests that universities should invest in both types of resources, but that the investment policy can be fitted towards specific needs, given the limited economic resources that modern universities have. As we can infer from students' temporal behavior, most of the printed material funding should go to those used in the early years of the degree and gradually decreased for courses toward the end of the degree, whereas access to electronic resources should be financed according to the number of student enrolled in the final years of their degree. Another way of interpreting the results of this article is with a focus on pedagogical implications. The above-mentioned recommendations consider how to make universities' current situation more economically efficient. However, we also assert that our analysis suggests that undergraduates' engagement with research occurs late in their degrees. Taking a more transformative perspective, we propose that libraries may play a key role in bringing research closer to students' experience earlier in their careers, getting them in contact with current research easily accessible through Electronic Resources. There has been much debate on the benefits of linking teaching and research and libraries may play a key role in realizing this nexus (see for example, Boyer Commission., 1999; Brew, 2011). For this to happen, changes in pedagogy are needed as university professors will need to advance from providing only text books during the first years (the current situation we saw in our study) towards designing and implementing learning tasks where students engage in searching and reading appropriate research articles.

This work has shown that use of library resources has an impact on students marks and that not all of the resources have the same size effect. Moreover, it has

shown that the access to library resources depends on the type of service, and that the amount of use depends on the year of the degree students are in. Our results are general and cannot give any information as to whether this pattern use depends on students' degree or some other demographic information, however they do agree with previous studies. The relational analysis between students' information and library services is significant for shedding light on the impact of the different library services on student learning and could be used to rationalize library investments and/or propose pedagogical development. The implications of our results suggest that university administrators should be aware of the relevant information hidden in their library managing systems: it could be used to make better decisions about library investments and pedagogical uses of the library.

Ideally, management systems should be compatible so they can be easily analyzed. Management systems can inform university policy decision and would be more valuable if they involve not only library services data but also other university services that are seen as valuable for the students.

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