



Patterns of Library Use by Undergraduate Students in a Chilean University

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abstract: This paper explores the patterns of use of print materials and digital resources in an undergraduate library in a Chilean university, by the students' discipline and year of study. A quantitative analysis was carried out, including descriptive analysis of contingency tables, chi-squared tests, *t*-tests, and multiple linear regressions. The results showed that the use of the library by undergraduate students did not follow a common pattern and instead varied across disciplines. The article also shows that access to digital resources does not replace the use of print materials.

Introduction

The publication by the Association of College and Research Libraries (ACRL) of its report *The Value of Academic Libraries: A Comprehensive Research Review and Report* in 2010 has proved to be of major relevance in the literature about the role of academic libraries within universities. The report acknowledged the main challenges libraries face, including increasing calls for accountability, economic constraints, high expectations from university stakeholders and users, and demands for libraries to demonstrate their value and contribution to student success and institutional missions.¹ Based on a literature review that shows the long-standing concern of academic libraries to better understand and assess their performance and impact, the ACRL report by Megan Oakleaf made important recommendations to academic libraries aiming to demonstrate their value to external and internal stakeholders. Since then, there has been a noticeable surge in research using databases gathered in university repositories to carry out studies seeking to better understand how libraries are used and the impact they have on users.

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In 2013, a multidisciplinary research team from the Pontificia Universidad Católica de Chile (Pontifical Catholic University of Chile, or UC) in Santiago started to work on a project to investigate student library use. For the first time in the institution, the researchers analyzed the complete library student usage logs in combination with centralized student records. The aim was to examine the patterns of library use and their links to student characteristics and performance. In this article, we present and discuss the initial findings regarding library use patterns for book loans and access to digital resources by the students' disciplines and years of study, and explore the relationship between them and student outcomes.

Literature Review

Since Oakleaf's report, the literature researching the use of academic libraries has grown considerably and now offers a wide range of perspectives to analyze the value of libraries for universities. A number of these studies explore the contribution of library use to student learning, student success, or other related variables, such as graduation, grades, retention rates, and learning engagement. Such work offers evidence of a positive link between library use and student success. See, for example, Brian Cox and Margie Jantti's 2012 study² and Deborah Goodall and David Pattern's 2011 research.³

Another interesting group of studies focuses on describing with different levels of details the patterns of library use by students, disaggregating them by diverse characteristics, such as year of study,⁴ academic discipline or faculty,⁵ gender,⁶ and other factors.⁷ These studies aim to better understand how students use services offered by the library. Researchers generally recognize that usage patterns will differ in different fields of study, and they explore these differences with the goal of improving and better tailoring their services for the particular needs of their users.⁸

Three aspects of these studies make comparison of their results difficult. The studies differ as to the library services included (for example, book loans, access to e-resources, or use of workstations), the source of the data used for the analysis, and the groupings used to describe the academic disciplines. Regarding the library services analyzed, the studies range from including all services offered by a library⁹ to other studies that consider only book loans, access to digital resources, and library visits.¹⁰ Additional difficulties result from the way the results are presented, either with each of the services separated or with all of them integrated.

In relation to the sources of data, the studies can be divided into two groups: those that use surveys, focus groups, or both, and those that use the data regularly collected and stored in library systems. Cox and Jantti explicitly criticize the use of surveys and focus groups because these methods are naturally biased to library users and collect only a subjective assessment of library value and performance.¹¹ Since Oakleaf's ACRL



report in 2010, many universities have implemented computerized systems to manage university services and store sociodemographic and academic information about students, providing objective data on the use of library resources.¹²

The studies reviewed show a wide range of methods to categorize and group the disciplines. Many studies use the actual college or faculty structure of the university to organize the data.¹³ Other authors use the courses or subjects as a basic level descriptor, which are then aggregated into discrete disciplines.¹⁴

These differences in the design and reporting of the studies make it difficult to compare the results. When we concentrate on analyzing those studies whose data source, discipline structure, and library services are closest to those in our study, their results were similar in some areas, but there were also substantial differences. The research conducted by Laurie Bridges in 2008 and by Shane Nackerud, Jan Fransen, Kate Peterson, and Kristen Mastel in 2013 found that students from engineering were less likely to access digital resources than students from other disciplines. Bridges found that the students with the highest probability of using digital resources were from the liberal arts, while Nackerud and his team determined that the highest level of users were in the area of education and human development. Ellen Collins and Graham Stone in 2014 found that health students had the highest median of access to digital resources, while computing and engineering and arts had the lowest median.¹⁵

In terms of the use of print materials, Nackerud and his coauthors found that design students accessed these the most, while business students accessed print materials the least. The results provided by Collins and Stone differed, finding that health students had the highest median of items borrowed at the library, followed by students in the humanities and social sciences, while computing and engineering had the lowest median.

The literature includes two accounts aiming to explain why the various disciplines use the library in different ways. The first account, by Deborah Goodall and David Pattern, states that the differences in library use by disciplines can be explained by differences in discipline-specific pedagogy: students in practice-based subjects such as arts or design may not be required to borrow books or to access digital resources as much as students from other disciplines such as the humanities, which tend to be more theoretical and which could be described as “reading-subjects.”¹⁶ The

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second explanation, by Yong-Mi Kim, suggests that usage patterns vary due to an epistemological difference, wherein each discipline requires a qualitatively different type of information that is accessible from different sources.¹⁷ In this view, business students would naturally use more digital resources, such as commercial websites, because they provide current information about real-world issues, while students from the humanities would use more print material because the information they need does not become dated quickly.¹⁸

If the disparities in usage patterns are due to epistemological differences, then the behavior of students in any given discipline should follow the same patterns regardless of the context. However, if the differences result from pedagogic approach, then the patterns of library usage may change according to each discipline's use of either a practical or theoretical approach. Considering that the studies reviewed here show results that vary substantially by disciplines, the variations could be explained by a combination of these reasons. Some disciplines present consistency in their patterns of library use; for example, engineering students' use of digital resources remains consistently high. Others, for example, health students, have variations due to the disciplinary emphasis in a particular university. These variations, though, are based on studies that are not fully comparable, and it would require more research to explore further the consistency of the results across universities and sites.

Among the studies reviewed here, the work of Xianjin Zha, Jinchao Zhang, and Yalan Yan stands out as particularly important. In their study, although the data were collected through a questionnaire, the researchers go beyond the production of patterns of usage

The main goal of our study was to explore whether there is a relationship between print material loans, the most used service of the library, and access to digital resources, and whether this relationship differs by academic discipline or year of study.

to describe interaction effects between the discipline and the experience the students had with library print and digital resources—for example, how long the student had been using these resources. The results show that the experience students had with print and digital resources influenced their perception of the usefulness and ease of use of digital and print resources, and that these relationships differed by disciplines (although the direction of the relationship was not explained). Additionally, Zha, Zhang, and Yan found that users with more than four years of experience with print

resources would more likely perceive their ease of use and usefulness, and would more likely use more digital resources than users with less experience. Unfortunately, these results were not disaggregated by discipline.¹⁹

Considering the need to explore further the usage of print and digital resources by discipline, this paper presents the patterns of loans of print materials and access to digital resources. It includes an analysis of use by discipline and year of study, focusing on the relationship between print material loans and access to digital resources, using the records gathered in the university's computerized systems. The main goal of our study was to explore whether there is a relationship between print material loans, the most used service of the library, and access to digital resources, and whether this rela-



tionship differs by academic discipline or year of study. Specifically, our study aimed to answer four questions:

1. Is there a relationship between print material loans and access to digital resources?
2. Does this relationship differ by academic discipline?
3. Does this relationship differ by year of study?
4. Do discipline, year of study, and level of access to digital resources have a combined influence on print material loans?

Methodology

The Pontificia Universidad Católica de Chile is a research-oriented university, comprising more than 23,000 undergraduate students distributed among 50 programs organized into 18 faculties. The data used for this study correspond to all undergraduate students enrolled in the first semester of 2013 ($N = 20,536$) and came from three institutional databases: (1) records of library loans and renewals of print material, such as books or journals, stored on the ALEPH (Automated Library Expandable Program) system; (2) authenticated access logs to digital resources in the library, stored on the EZproxy database, through which authenticated off-campus users access online library resources; and (3) student academic and demographic information available from the DARA (Admissions and Academic Registry Directorate) database of central student records. All this information was merged to build a single data set using a single student identifier that was later encrypted to protect anonymity. The data extracted from each database were the following (Table 1 shows the names and descriptions of the variables used in this study):

- Number of loans and renewals by each student in a specified term (ALEPH).
- Number of log-ins by each student, which were divided into 10-minute periods, following Cox and Jantti; in this way, only one access was counted if the student had consecutive log-ins within a 10-minute period. If the online activity of the student lasted longer than 10 minutes, additional log-ins were added (EZproxy).
- Students' program of study, year of study, average grade, and other background information (DARA).

The data included students from 39 different undergraduate programs. To manage this information, the programs of study were grouped into five disciplines. These disciplines were adapted from the classification of disciplines used by the Organisation for Economic Co-operation and Development (OECD).²⁰ The final list of disciplines and the programs included in each are shown in Table 2.

To explore the relationship between print material loans and access to digital resources by discipline and year of study, a quantitative analysis was carried out including descriptive analysis of the single relationship using a variety of statistical techniques. These techniques included contingency tables, which show the interrelation of two variables, to study the association between the variables; chi-squared tests, employed to compare observed data with the results expected and to confirm association between two variables; and *t*-tests, which indicate whether a difference between two groups' averages reflects a "real" difference in the groups rather than a difference that occurred



Table 1.
Names and descriptions of variables

Name	Description	Database
Number of print material loans	Number of print materials borrowed by each student during the semester. A renewal is counted as a second loan.	ALEPH (Automated Library Expandable Program)
Print material use	Dummy variable that groups students who borrowed at least one print material during the semester (1) and those who did not borrow any print material (0).	ALEPH
Number of digital resources accesses	Number of 10-minute blocks of authenticated log-ins during the semester.	EZproxy
Digital resources use	Dummy variable that groups students who had at least one 10-minute period of consecutive actions as an authenticated user in the semester (1) and those who had no actions in the same period (0).	EZproxy
Discipline	Five areas that group the undergraduate programs: (1) natural sciences, (2) engineering and technology, (3) medical sciences, (4) social sciences, and (5) humanities.	DARA (Admissions and Academic Registry Directorate)
Year of study	Number of years enrolled in the university with a limit of eight years (99.4% of cases). More than eight years are considered extreme cases or system errors.	DARA
Standardized average grade	Students' average grade, including all courses taken by each student at the given semester, standardized by its program (z-score).*	DARA

*A z-score is a measure of how far any score diverges from the most probable result, the mean.



Table 2.
Disciplines and the corresponding programs of study

Discipline	Programs of study
Natural sciences	Marine biology, biochemistry, biological sciences, astronomy, physics, mathematics, chemistry, chemistry and pharmaceutics
Science and technology	Agriculture and forestry, civil construction, engineering
Medical and health sciences	Nursing, phonoaudiology, kinesiology, medicine, nutrition, dentistry
Social sciences	Anthropology, architecture, political science, law, geography, business administration, teacher education, media studies, advertising, communication, psychology, sociology, social work
Humanities	Drama, art, design, aesthetics, philosophy, history, literature, music, theology

because of random chance in the sample selection. This analysis aimed to show if there is a relationship between print material loans and access to digital resources, and whether this relationship varies across disciplines and year of study. A multiple linear regression was carried out to examine the nature and strength of relationships between variables; this regression aimed to observe the relative weight of each explanatory variable in predicting the dependent variable.

Results

Relationship of Print Loans and Digital Access

To start exploring the relationship between print material loans and access to digital resources, the variables were analyzed independently of the students' academic discipline. Comparing the proportion of students who borrowed print materials given their access to digital resources, it was found that students who accessed digital resources showed higher probabilities of borrowing print materials than those who did not access digital resources. Seventy-four percent of students who accessed digital resources borrowed print materials at the library, while only 68 percent of

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Table 3.

Print material loans by access to digital resources

	Number of students who borrowed print materials	Percentage of students who borrowed print materials	Average print material loans per student
Not accessed digital resources	11,195	67.8%	19.7
Accessed digital resources	2,993	74.4%	23.9
Total	14,188	69.1%	20.6

those who had not accessed digital resources did borrow print materials: $\chi^2(1) = 65.59$; $p = 0.00$ (see Table 3). Comparing the number of print material loans per student who had at least one loan, given students' digital resource access, we found larger differences in the number of print materials loaned. Considering only the students who borrowed at least one print item during the semester and had accessed digital resources, those students borrowed on average four more print items than those who did not access digital resources, with a small effect size: 23.9 versus 19.7 print material loans on average, respectively: $t(4149.7) = -7.19$; $p = 0.00$; $d = 0.16$. This result shows a relationship between the number of print material loans and access to digital resources, because students who accessed digital resources borrowed more print materials than those who did not. It also reveals that accessing digital resources does not replace the use of print materials. Moreover, these data show that the use of one resource promotes the use of the other.

Relationship of Print Loans and Digital Access by Discipline

The analysis was then expanded to whether the relationship between print material loans and access to digital resources showed any differences by discipline. Firstly, the researchers explored whether there were disciplinary differences in each type of resource separately (digital and print). A descriptive analysis comparing the proportion of students who borrowed print materials during the semester by discipline is shown in Table 4. Students in programs from social sciences and science and technology are less likely to borrow at least one print item from the library, compared to students in other disciplines. In contrast, students from natural sciences and humanities are more likely to borrow print materials. A slightly different trend was found when comparing the averages of print material loans among students who borrowed at least one print item. Science and technology students have the lowest average (14.2). Social sciences (19.1) has an average similar to medical sciences (19.2), and both are marginally lower



Table 4.
Print material loans and digital resources access by discipline

Discipline	Percentage of students with loans of print material	Mean*	Percentage of students with access to digital resources	Mean*
Natural sciences	83.4%	24.2	26.9%	18.9
Science and technology	65.6%	14.2	11.8%	16.4
Medical and health sciences	70.9%	19.2	43.5%	40.1
Social sciences	65.1%	19.1	19.5%	15.1
Humanities	82.9%	35.9	13.2%	9.9
Total	69.1%	20.6	19.6%	20.5

* The mean for print material loans and access to digital resources are from students with at least one loan or access per semester.

than the general average (20.6). In contrast, humanities has the highest average of print material loans per student (35.9), while natural sciences (24.2) has an average above the mean but not as high as the humanities.

Regarding access to digital resources, considering the students who access materials at least one time in the semester, the analysis found that students from science and technology and humanities are the least likely to access digital resources (11.8 percent and 13.2 percent, respectively) and also have the lowest average of access (16.4 percent and 9.9 percent, respectively). Conversely, students from medical and health sciences are the most likely to access digital resources (43.5 percent) and have the highest average of access (40.1). Based on these results, it is possible to conclude that the patterns of print material loans and digital resources access among students show differences by discipline.

Differences by Disciplines on Use of Print Material and Digital Resources Combined

Once the disciplinary differences on the use of each type of library resource were confirmed, a second phase of the analysis was carried out, where both resources were combined and examined to identify whether the relationships identified earlier hold across disciplines. Different patterns emerged when connecting the number of students who borrow print materials by their access to digital resources by disciplines. Table 5 shows

Table 5.

Percentage of students who borrow at least one print item from the library by access to digital resources and discipline

	Percentage of students who borrow print materials		χ^2 †	p ‡
	With digital resources access	Without digital resources access		
Natural sciences	81%	84%	1.79	0.18
Science and technology*	69%	65%	4.81	0.03
Medical and health sciences*	67%	74%	11.74	0.00
Social sciences*	75%	63%	91.37	0.00
Humanities*	95%	81%	36.60	0.00
Total*	74%	68%	65.59	0.00

* Differences are significant at the 0.05 level.

† χ^2 (chi-squared) tests are used to compare observed data with the results expected. The larger the chi-squared value, the greater the probability that a significant difference exists.

‡ The p -value gives the likelihood that any effect seen in the data, such as a difference in means between groups, might have occurred by chance.

the percentage of students who borrowed at least one print item by their access to digital resources and by discipline. Science and technology, social sciences, and humanities show the highest probability of borrowing print material given their digital resources access, a relationship that matches the general trend found in previous research. However, medical and health sciences show an inverse relationship, wherein students who did not access digital resources have a higher probability of borrowing print material than those who accessed digital resources, 74 percent versus 67 percent, respectively: $\chi^2(1) = 11.737$; $p = 0.01$. In contrast, there were no significant differences in natural sciences between those who access or do not access digital resources: $\chi^2(1) = 1.794$; $p = 0.18$.

Similarly, when comparing the number of print material loans of students with at least one loan by their digital resource access and taking into account the discipline, new patterns arise. Figure 1 shows the average of print material loans in relation to the students' digital resource access and discipline. This diagram reveals that students of science and technology, social sciences, and humanities disciplines with digital resource access have higher numbers of print material loans. Humanities students stand out as the group with the greatest difference, with an average of 21 extra loans and a moderate

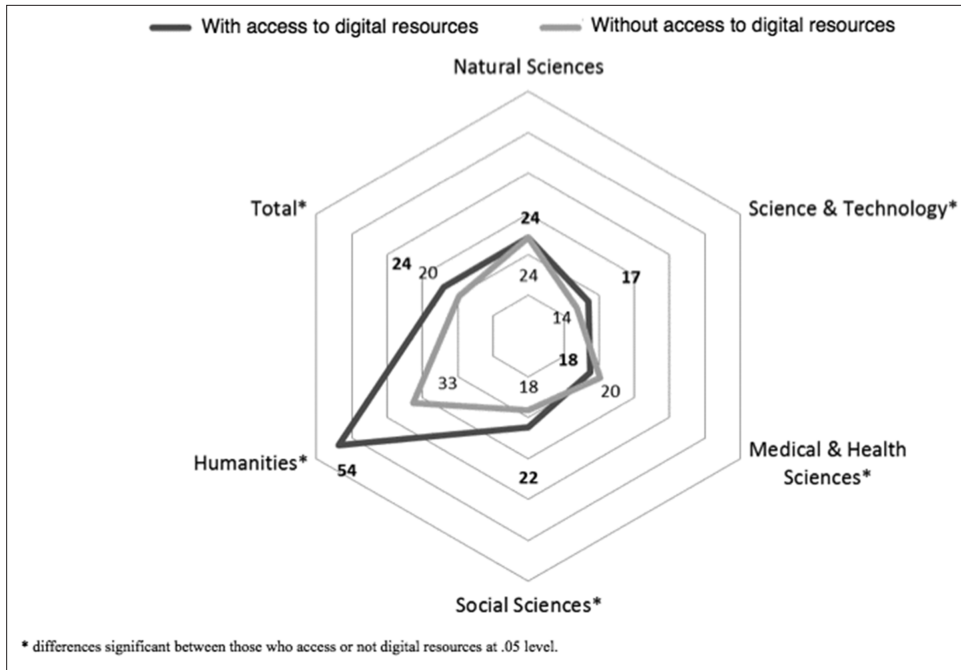


Figure 1. Average of print material loans by access to digital resources and discipline

effect size: $t(333.9) = -6.24$; $p = 0.00$; $d = 0.45$. Consistent with previous results, students of natural sciences show no differences in the average number of print material loans, whether they access digital resources or not. Medical and health sciences students exhibit a different behavior: students who accessed digital resources borrowed, on average, fewer print materials than those who did not access these resources. We suggest that there is an interaction between access to digital resources and discipline in relation to the number of print material loans. In other words, the difference between the average of print material loans by those who access digital resources and those who do not increases or decreases according to the student's discipline.

Relationship of Print Material Loans and Digital Resources Access by Discipline and Year of Study

When disaggregating the relationship between print material loans and digital resources access by both discipline and year of study, humanities appears as an interesting case. As can be seen in Figure 2, students from humanities who access digital resources borrow more print material than those who do not access digital resources. This relationship is maintained and is statistically significant in the first five years of study. Although it is possible to observe a shift in this tendency in year six, this difference is not significant, which could be explained by the small number of students included in these later years (year six, $n = 54$; year seven, $n = 13$; year eight, $n = 5$), because programs of study in the humanities last only five years.

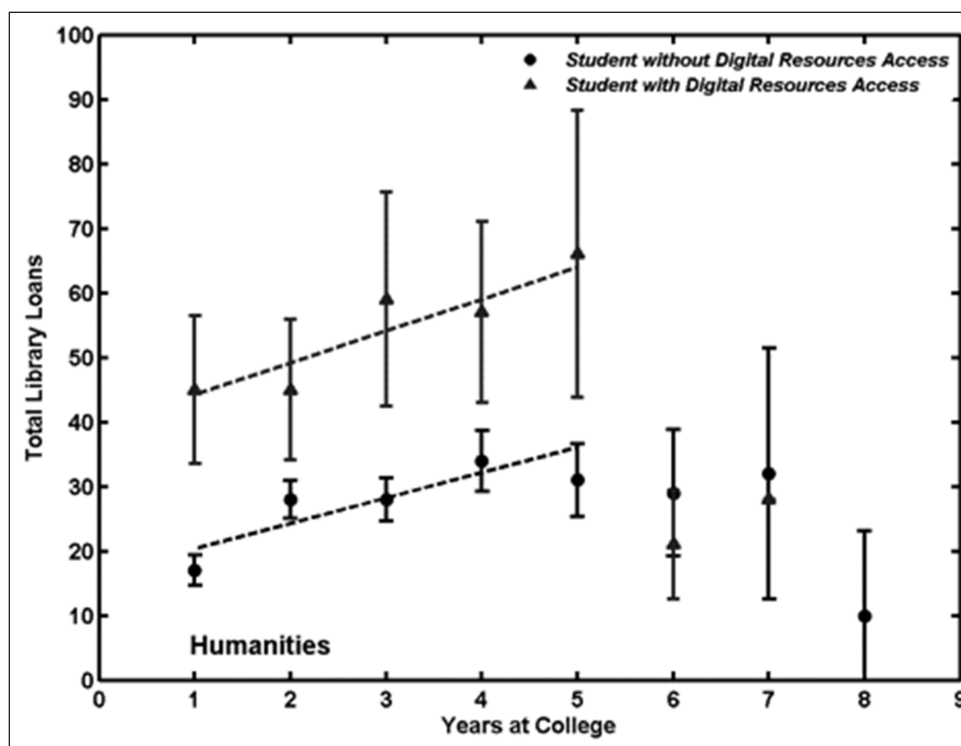


Figure 2. Average of print material loans by access to digital resources and year of study for students in humanities

Another interesting case is medical and health sciences. As shown in Figure 3, medical and health sciences students who accessed digital resources tended to borrow less print material than those who did not access digital resources. This relationship actually disappears when it is disaggregated by year of study. This difference can be explained because both groups (students who do not access digital resources and those who do) present different patterns. In the group of students who do not access digital resources, more than half are concentrated in the first two years of study, where the average of print material loans is much higher than in the later years. Therefore, the total average is closer to the average of loans in the early years. In contrast, in the group of students who do access digital resources, the print material loans tend to concentrate between years three and five, when on average students borrow fewer print materials than in the early years of study. As a result, when the data are aggregated to obtain the average per group, the average of those who access digital resources becomes similar to the average of those in the middle years of study.

In the rest of the disciplines analyzed, there were no distinct patterns of differences by year of study for print material loans between those who access and those who do not access digital resources. There was, however, an interesting relationship between the average of print material loaned and year of study by discipline, independent of access to digital resources. These patterns are represented in Figure 2 and Figure 3. Figure 2

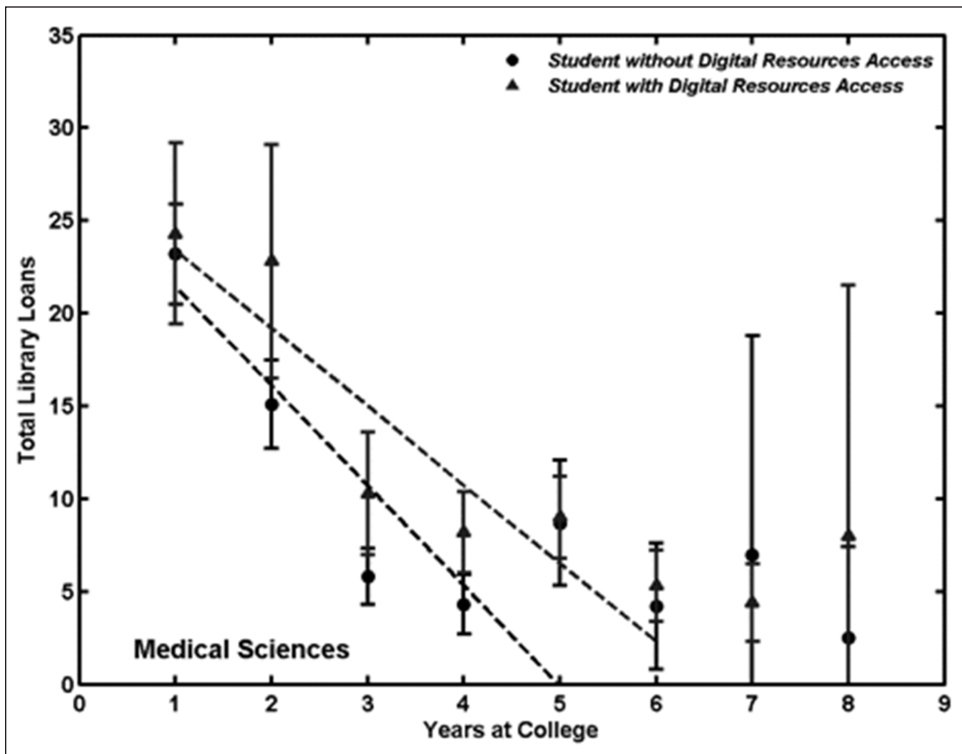


Figure 3. Average of print material loans by access to digital resources and year of study for students in medical and health sciences

shows that, independent of access to digital resources, students from humanities tend to increase their print material loans as their years at college pass: $r = 0.11$, $p = 0.00$. The same trend occurs for students in the social sciences: $r = 0.06$, $p = 0.00$. However, the opposite tendency is found in medical and health sciences, engineering and technology, and natural sciences, in which students tend to decrease their loans of print materials as the years progress: $r = -0.29$, $p = 0.00$, $r = -0.07$, $p = 0.00$, and $r = -0.23$, $p = 0.00$, respectively (see Figure 3).

Combined Influence of Digital Resources Access, Discipline, and Year of Study on Print Material Loans

Once the relationships between the variables under study were identified, a multiple linear regression analysis was performed to predict the logarithm of print material loans to observe the combined influence on print material loans of access to digital resources, discipline, and year of study. The logarithm of print material loans was used to normalize distribution.

The starting model was to test the influence of digital resources access, discipline, and the interaction between the two on the log of print material loans. A significant regression equation was found: $F(9, 14178) = 111.62$, $p = 0.00$, with an R^2 of 0.066, as shown



in Table 6. This model confirms the results of the descriptive analysis. Digital resources access, discipline, and the interaction between them all prove significant predictors of print material loans.

In relation to the reference category (that is, science and technology), humanities shows the greatest positive difference ($B = 0.8$, $t = 23.72$, $p = 0.00$), followed by natural sciences ($B = 0.6$, $t = 14.25$, $p = 0.00$). The variable access to digital resources also presents a positive relationship, but its magnitude is smaller than that of the discipline ($B = 0.25$, $t = 4.35$, $p = 0.00$). Moreover, the interaction between discipline and access to digital resources is confirmed. The effect of access to digital resources on the log of print material loans is greater for students in humanities than for students in science and technology ($B = 0.3$, $t = 3.31$, $p = 0.00$). In contrast, studying a program in natural sciences or in medical and health sciences and accessing digital resources decreases the positive fixed effect of accessing digital resources on the dependent variable ($B = -0.33$, $t = -3.58$, $p = 0.00$; and $B = -0.45$, $t = -5.49$, $p = 0.00$, respectively). For social sciences, the interaction is not significantly different from the reference category ($p = 0.42$).

The second model employed expanded the analysis by adding the predictor year of study and the interaction between this and the discipline. For this analysis, the standardized average mark of students was included as a control variable.

This second model explains 8.6 percent of the dependent variable variance: *Ad. $R^2 = 0.086$* , $F(15) = 89.935$, $p = 0.00$. The model presents an Akaike information criterion and a Bayesian information criterion, two information measures of the model fit for a given set of data, lower than those of the first model. This means that, accounting for the variables added, the second model is better than the first. In this model, the relationship between discipline and access to digital resources is maintained, except for the social sciences, where the relationship becomes negative but not significant ($p = 0.50$). The year of study has a negative relationship with the dependent variable but only significant at a 0.10 level ($B = -0.02$, $t = -1.69$, $p = 0.09$). This relationship varies according to the student's discipline, and this negative relationship is stronger for students in natural sciences and medical and health sciences programs. This means that students from these two disciplines tend to borrow fewer print materials as years pass, in comparison with the reference category. In contrast, the relationship between years of study and loans of print materials becomes positive for students in social sciences and humanities programs.

The interaction between discipline and access to digital resources becomes not significant at a 0.05 level, except for humanities, where the relationship continues to be positive and significant ($B = 0.29$, $t = 3.18$, $p = 0.00$). The standardized average marks have a positive relationship with the dependent variable.

Finally, observing the magnitude of the relationship between the dependent variable and the explanatory variables, the discipline and its interaction with the year of study are the variables that most affect the loans of print materials. The interaction between discipline and digital resources access is significant only for students in the humanities.

Discussion

This study aimed to observe the relationship between two services provided by the university library—print material loans and the access to digital resources—and to analyze



Table 6.
Predictors of log of print material loans

Variable	Log of print material loans			
	Model 1 B†	Model 2‡		
		B	95% confidence interval§	
Constant	2.10**	2.15	[2.08,	2.22]
Discipline				
Natural sciences	0.60**	0.94**	[0.79,	1.08]
Medical and health sciences	0.34**	0.78**	[0.65,	0.91]
Social sciences	0.19**	−0.03	[−0.12,	0.06]
Humanities	0.80**	0.45**	[0.33,	0.58]
Access to digital resources	0.25**	0.26**	[0.14,	0.37]
Year of study	−0.02*	[−0.04,	0.00]	
Standardized average mark	0.04**	[0.02,	0.06]	
Interaction: Discipline by access to digital resources				
Natural sciences by access to digital resources	−0.33**	−0.15	[−0.34,	0.03]
Medical and health sciences by access to digital resources	−0.45**	−0.05	[−0.23,	0.12]
Social sciences by access to digital resources	0.05	−0.01	[−0.14,	0.12]
Humanities by access to digital resources	0.30**	0.29**	[0.11,	0.47]
Interaction: Discipline by year of study				
Natural sciences by year		−0.14**	[−0.18,	−0.09]
Medical sciences by year		−0.22**	[−0.27,	−0.18]
Social sciences by year		0.08**	[0.05,	0.10]
Humanities by year		0.12**	[0.08,	0.16]
#R ²	0.066		0.087	
††F	111.62**		89.94**	

N = 14,110. Discipline reference category: science and technology.

* $p < 0.10$; statistically significant at the 0.10 level (two-tailed); the p -value gives the likelihood that the effect seen in the data, such as a difference in means between groups, might have occurred by chance assuming the null hypothesis is true.

** $p < 0.05$; statistically significant at the $p < 0.05$ level.

† Model 1: Akaike information criterion = 2,821.28; Bayesian information criterion = 2,896.88.

‡ Model 2: Akaike information criterion = 2,494.42; Bayesian information criterion = 2,615.29.

§ There is a 95% chance that the value of each coefficient falls between the lower and upper bounds of each confidence interval.

R² (R-squared), the coefficient of determination, is the square of the correlation between the value the model predicts (for the dependent variable) and the actual (observed) dependent variable. It represents the proportion of the variance in the dependent variable that is explained by the model. Change in R² from Model 1 to Model 2 = 0.021.

†† Both F values indicate that the predictive power of this combination of variables can likely be attributed to factors other than chance alone. Change in F from Model 1 to Model 2 = −21.78.



them by discipline and year of study for undergraduate students. Our main result is that there is a relationship between access to digital resources and print material loans. Students who access digital resources are more likely to borrow print materials and have a higher average of print material loans than those who do not access digital resources. We also found that this relationship changes according to discipline. The magnitude of the effect of access to digital resources is greater in some disciplines than in others. Fur-

For humanities and social sciences, the average of print material loans increases along with the students' years of registration, but it decreases for medical and health sciences, science and technology, and natural sciences.

print material loans increases along with the students' years of registration, but it decreases for medical and health sciences, science and technology, and natural sciences. Although there is a corresponding relationship between print material loans and access to digital resources, the discipline and its interaction with year of study have a greater impact on predicting print material loans.

The results obtained by our study support the findings reported in previous studies, which found that students from science and technology have the lowest probability of accessing digital resources.²¹ However, our findings differ from the results presented by Nackerud and his team in 2013 regarding the group that has the highest probability of accessing digital resources. We found that students from medical and health sciences are most likely to access digital resources, while Nackerud and his coauthors found that students from the College of Education and Human Development were the most likely to do so.²²

Regarding the average number of log-ins to digital resources per student, we found similar results to those presented by Zha and his team. In our data, students in the hu-

Students in the humanities appear as the group with the lowest average number of log-ins to digital resources, followed by students in science and technology.

manities appear as the group with the lowest average number of log-ins to digital resources, followed by students in science and technology.²³ These results differ slightly from the results presented by Collins and Stone, who found that science and technology and arts were those with the lowest average. However, this mismatch may be explained by the fact that we used a disciplinary area that merges arts with humanities, so the results for the humanities could be influenced by the low average of the arts.²⁴

In relation to the use of print materials, we found similar results to those reported by Nackerud and his group, although with a different level of magnitude. They found that

Further, the relationship between print material loans and access to digital resources holds only for humanities when it is disaggregated by year of study.

However, we found an interesting relationship between discipline and year of study that is independent of access to digital resources. The analysis showed that for humanities and social sciences, the average of

manities appear as the group with the lowest average number of log-ins to digital resources, followed by students in science and technology.²³ These results differ slightly from the results presented by Collins and Stone, who found that science and technology and arts were those with the lowest average. However, this mismatch may be



students from the College of Design had the highest probability of using print materials; 37 percent of them borrowed at least one item in the period studied. Students from the business school were the least likely to use print materials; only 13 percent of them borrowed at least one item during the same period. While we found a similar pattern in our study, we classified design with humanities and business with social sciences, and our results differ on the proportion of students who use print materials.²⁵ According to our data, the proportion of students who borrowed at least one print item in the term was 83 percent and 65 percent, respectively. This difference in magnitude could be explained by the level of digitization of the libraries' collections. University libraries in the United States have greater numbers of books available in digital form than universities in Chile, where most books are still only available in print.

Regarding which of the disciplines present the highest number of loans per students, our results do not match those of Collins and Stone's 2014 report. Our data show that the humanities is the discipline with the highest average number of loans per student, while Collins and Stone report the highest usage in the medical and health sciences. In their study, however, the humanities has the second highest median and is similar to social sciences. This difference could be explained by the fact that we used the average of print materials borrowed per students who borrowed at least one item, and Collins and Stone used the median.²⁶

As previously indicated, in our study we identified an association between print material loans and access to digital resources that varied according to the discipline (as shown in Figure 1). In this way, students from the humanities, social sciences, and sciences and technology disciplines tended to borrow a higher number of print materials if they had accessed digital resources. In contrast, students from the medical and health sciences who had accessed digital resources tended to borrow, on average, fewer print materials than those who did not access digital resources. However, this relationship does not hold when it is disaggregated by year of study. This association was confirmed by a multivariate analysis, a statistical technique used to analyze data from more than one variable, where the interaction between access to digital resources and discipline was seen to have a significant influence on predicting print material loans. This relationship represents an interesting contribution on patterns of library use because no other study made the connections we report here. The study by Zha and his coauthors at a Chinese university was partially similar, because they found that the perception of ease of use and usefulness and the use of digital and print materials are influenced by the experience with both types of resources, a relationship that differs by discipline.²⁷

There was no clear pattern when the association between print material loans and access to digital resources was disaggregated by discipline and year of study. However, an interaction effect was found between print material loans and year of study by discipline. In a multivariate analysis, we introduced all of the single relationships found in the descriptive analysis and found that print material loans depended more on the student's discipline and year of study, and less

Print material loans depended more on the student's discipline and year of study, and less on access to digital resources.



on access to digital resources. Only for students in the humanities was this interaction between access to digital resources and the discipline statistically significant. However, its influence is small in comparison with the influence of the other variables. Among all the possible patterns, two are clearly distinguished. For one group of programs of study, there is an increase of print material loans over the years (an effect that increases with the access to digital resources). For another group of programs, there is a decrease of print material loans over the years (an effect that is moderate when considering the access to digital resources). Therefore, the effect of access to digital resources is complementary to the print material loans.

The first pattern (print material loans increase over the years) is present in the humanities and social sciences, where the effect of one additional year increases the log of print material loans in 0.10 and 0.06 respectively, reversing the negative pattern of the year of study fixed effect ($B = -0.02$, $t = -1.69$, $p = 0.09$). Moreover, the access to digital resources increases this effect in 0.55 and 0.25, respectively.

The second pattern (print material loans decrease over the years) is present in medical sciences, natural sciences, and engineering and technology. In these disciplines, as the years progress, the log of print material loans decreases in 0.24, 0.16, and 0.02, respectively. This effect weakens slightly if the students access digital resources, in 0.21, 0.11, and 0.26, respectively.

A possible answer for the tendency of the first group, humanities and social sciences, could be that students in these programs tend to have more general knowledge courses in their first years of study. For these courses, they use books available in the library,

The use of academic libraries by students does not follow a common pattern. Instead, the pattern changes according to the discipline of study.

because the subjects do not become outdated too quickly. Later, they start using digital materials that provide more current and updated information, required for more specialized and professional courses. This behavior could explain the increase in print material loans over the years and the interaction with the access to digital resources. In opposition, students in medical sciences programs do internships in their last years, usually in hospitals outside the university campus and,

therefore, away from the physical library building. Their off-campus location would explain their tendency to borrow fewer print materials as they progress in their programs.

Reviewing these findings, and even if the division of the disciplines may be considered arbitrary, these results show that the use of academic libraries by students does not follow a common pattern. Instead, the pattern changes according to the discipline of study. The findings also show that access to digital resources has a complementary effect on print material loans, although its influence is smaller than that of the discipline and year of study when predicting the number of print materials borrowed.

Conclusions

The findings of this study represent an important input for academic library managers because they show that the use of print materials is complementary to the access to digi-



tal resources. Accordingly, access to digital resources does not replace the use of print materials. The complementary relationship that we have established between print and digital resources represents our most relevant contribution to the field.

Moreover, some disciplines, such as the humanities and social sciences, do not follow the general pattern of decreasing print material loans through years of registration; instead, print material loans tend to increase over time, a trend that is reinforced when students access digital resources. Considering this, we suggest that all activities orientated to promote the use of the library should consider the patterns found for each discipline as well as the complementary nature of both print and digital resources. These results offer academic library managers a better understanding of how undergraduate students behave across disciplines and years of study in relation to print material loans and access to digital resources. The findings may allow library managers to design strategies that can increase usage and the impact of libraries more broadly, by tailoring their resources to the different patterns identified.

Research like this is important because it provides academic libraries new insights into how students use academic resources. Such findings become particularly relevant when academic libraries experience increasing pressure to justify and be accountable for the funds received. Such pressure is particularly the case in developing countries like Chile.

Some questions still remain unsolved and should be considered for future studies, particularly by qualitative explorations of specific undergraduate programs. One particular issue would be to explore why students from some disciplines, such as natural sciences, medical sciences, and science and technology, borrow fewer print materials as they progress in their programs, while other disciplines, such as the humanities and social sciences, present an inverse pattern.

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