Building a "Library Cube" from Scratch

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Introduction

Library assessment research in academic libraries has grown over the last several years with a particular emphasis on measuring the effects of library resources on student success (often GPA and retention) to demonstrate value and impact.[1] Through assessment departments, often in partnership with institutional researchers, academic libraries can build foundational datasets important for reporting value and impact. At Florida State University (FSU), these efforts within departments and divisions have resulted in silos of data that speak to temporary or singular questions or decisions. However, when brought together, these data might impact broader decisions and gain attention from campus administrators with influence over budgeting and resource allocation. These studies might be momentarily compelling or important for specific divisions but could contribute to telling the larger story about the collective impact of an academic library's services, spaces, and resources. Building a multidimensional data warehouse could help an institution gather and connect these studies and datasets in one unified database for easy querying and reporting. Translating this concept for use within academic libraries, we will discuss the many steps involved in planning a library cube. Ultimately, this database brings together measures of student demographics, resource usage, and outcomes such as GPA and retention rates. This enables assessment librarians and administrators to make connections between the impact of library services, spaces, and collections on student success in a more cohesive and organized way. Additional environmental factors could include instruction and learning, grades, extracurricular activities, parental educational attainment, use of other campus resources, jobs after graduation, etc. A library cube can help libraries streamline data analysis and reporting integral to engaging with campus decision-makers, which is especially helpful in navigating a higher education landscape that emphasizes performance metrics and demonstrations of value and impact.

Ideally, these advancements will lead to multidimensional, real-time datasets from which library stakeholders could ask research questions using myriad variables at the point of query. Standardized data could automatically be pulled from different data sources already cleaned, merged, stored, and ready to use. Data points on library usage, such as circulation, equipment borrowing, tutoring services, study rooms, library databases, and working with librarians, can all be linked via a unique identifier with student demographics, pre-college, and engagement variables. This, when combined with institutional research data, such as student grades, course load, major, and GPA, can then be used to gauge usage and trends of library use and services among the student population that uses the library. Academic libraries should engage in many discussions about the theoretical and empirical reasons for including certain variables regarding libraries and student success. Taken together, these variables should facilitate the most complete framework for understanding the impact of libraries on students, making their collection and selection particularly important in the decision-making process. There are many models on the various factors affecting student success that might be of value to libraries when making these decisions, for example, Astin's Input-Environment-Output (I-E-O) Model of Student Involvement.[2] By increasing the number of data sources available for analysis, a more complete and comprehensive picture can be provided of the impact of library usage on student and faculty success.

Background of the Cube Concept

In 2010, before there was any mention of a Library Cube, ACRL's Value of Academic Libraries (VAL) Initiative was an impetus for academic libraries to measure their impact on student success outcomes (through the Assessment in Action [AiA]: Academic Libraries and Student Success program).[3] Since then, many academic libraries through AiA have collected data that measure the relationship between library usage and impact on student success outcomes, often with an emphasis on specific aspects of the library experience (e.g., space, instruction, equipment use, database use, etc.) on one or more student success outcomes (e.g., student learning, retention, engagement, GPA, etc.).[4] In addition to AiA's collection of

research, there have been research studies measuring the effects of an array of library usage points on a number of student success factors, such as at the University of Minnesota or, in the case of the Library Impact Data Project, multiple variables at multiple institutions at once.[5]

University of Wollongong

Academic libraries have long struggled with how to demonstrate value and impact using all the data they collect in an organized, accessible, and streamlined way. The UOW Library was the first of a few university libraries in the world who addressed this issue. They created a system that, for them and their data, served this purpose and set the stage for other academic libraries to follow. This is especially important as qualitative and quantitative data about library usage is being collected from library staff of services from all facets of the library, yet the data remains siloed into separate streams of library evidence.

In 2012, the UOW Library in New South Wales, Australia, described their creation of a database—its moniker "Library Cube"—that combined library use data with student data to determine library impact and value.[6] At the Library Assessment Conference in Seattle, Washington (August 2014), attendees learned about the progress of UOW's Library Cube, a relational database that tied together aggregate student data to reveal that there was, in fact, a positive relationship for students using separate library information measures (using EZProxy logs and number of circulations) on student academic performance.[7] Using this interactive data warehouse, they rescued data from existing silos and made it possible to create standardized and customizable reports. To address these issues, the UOW "developed the Library Cube, a tailored database and reporting function that joins library usage data with student data, including demographic and academic performance information."[8] As a result of bringing the data of library information usage, student demographic, and success variables together (e.g., student grades), they were able to discover relationships to tell a more evidence-based story of the library's impact and value at their university. This ultimately helped them build an infrastructure to measure multiple dimensions of library value, not just using traditional measures of library.

Furthermore, UOW's Library Cube enabled their library administration to securely access an array of data and analyze it by using an in-house, web-based UOW-wide "Performance Indicators Portal" provided by UOW's Performance Indicators Unit.[9] Their portal resembles the business intelligence software that the Office of Institutional Research provides access to different FSU stakeholders. UOW Libraries started building the Cube with circulation (loans) and online resources data by looking at time series data.

University of Huddersfield

In addition to the introduction to the Cube concept from UOW, the Library Impact Data Project, a collaboration between the University of Huddersfield and JISC, a digital support company serving the educational sector in the UK, measured students across three universities (over 30,000 students) using multiple dimensions of student library usage to examine its relationship with student degree attainment.[10] One of the most comprehensive studies of its kind, researchers also needed to develop elements of a library cube to connect the student usage and success measures across three universities.

As the concept grew in theory and practice across these institutions, it simultaneously revealed the need to manage, warehouse, and de-silo data necessary for analyzing the many ways that library usage and engagement can collectively impact student outcomes. In the United States, Kennesaw State University (KSU) and the University of Minnesota (UMN) Libraries have emerged as leaders in library cube development.

Kennesaw State University

KSU Library replicated the work done by UOW to develop their own LibCube project and found the same strong correlation between library resource usage and higher student GPA.[11] The library was able to partner with the KSU Office of Institutional Research and campus administration to collect, analyze, and publish their findings. KSU administration realized the value of this type of assessment and committed early on to buying the SAS statistical suite and Tableau for campus wide use. The Office of Institutional Research was

able to leverage this investment and start a campus-wide project to measure student success in other areas beyond the library. The KSU Office of Institutional Research also provided expertise in data analysis and data visualization to the library and other university departments.

University of Minnesota

The Library Data and Student Success project, which keeps track of individuals' IDs and general library use, is stored separately from other library data because of the way various projects have evolved. However, the University of Minnesota has been waiting for their university's organizational data office to bring LDSS data together with other library data to create a more complex database moving forward.

In the meantime, and for the last seven years, people from around the libraries send data to their organizational data strategist or give them access to pull the data needed for additional analyses. They use a Microsoft Access database stored on an Office of Institutional Research (OIR) server that includes demographic data as needed from PeopleSoft. The strategist does not store anything locally, for data privacy and security reasons. Although there is a need to retain student IDs in order to do longitudinal studies, any spreadsheet or other derivation of the data at the individual level (rather than, say, aggregated by college) is anonymized and the actual ID is only kept on the OIR server.[12]

Florida State University

FSU Libraries' Assessment Department—influenced by the VAL initiative and a campus-wide push to measure how library spaces and services impacted student success—conducted two studies. The first, beginning in 2010, collected longitudinal data from a library-intensive course and measured the effects on student GPA and graduation rates.[13] The second major study examined card swipe data to estimate the effects of library visit duration and frequency of visits on first-time-in-college (FTIC) students' GPA and retention rates.[14] Both of these studies and their continued data collection have made it clear that we need to integrate large data sets, such as card swipe data, with other disparate library usage data sets with student outcomes. By rebranding the library cube as LibCube at FSU Libraries, we initiated planning to create a centralized, searchable, and accessible database to decision-makers that is connected to de-identified student data—the process for which we outline in this paper.

Purpose

The purpose of this paper is to describe the process used at FSU Libraries for building a multidimensional library database or "Library Cube" from scratch to make this process easier for others to develop, identify various challenges, including technical and ethical issues, and to build on library cube trends established by UOW, UMN, KSU, and the Library Impact Data Project (University of Huddersfield and JISC).

As previously demonstrated by the institutions at the forefront of these efforts, library cubes can enable data-driven decision-making for internal stakeholders, provide access to data for real-time queries and standardized reports, link data together with common identifiers across internal and external institutional information or outcomes, and allow for cross-sectional and trend studies of library services and impact. Academic libraries will find a library cube particularly useful for linking the use of library resources with student success, for improving decision-making about resource allocation in the library and seeing whether services are effective and how they can be improved.

Getting Started with a Library Cube

Library and Campus Environmental Scan

After conducting our initial research on the use and development of a LibCube, it became obvious that we would need to look outside of the library for resources and expertise. We reached out to other campus units to gauge interest in forming partnerships. What we discovered was that several units on campus were already working on similar projects. We found that both the Office of Institutional Research and the Office of Distance Learning were both conducting research linking use of university resources to student success. Though both campus units were working towards the same goal, they were not collaborating on the project. They were also using different techniques for storing and analyzing their data. The Office of Distance

Learning had invested considerable resources in developing on-premise big data analytical capabilities. The Office of Institutional Research had just recently started the process of moving to a third-party cloud-based vendor for data analysis.

These two approaches are common when analyzing big data and have their advantages and disadvantages. In-house solutions provide greater control but have the usual drawbacks of technology upkeep and management. The cloud-based solution eliminates these drawbacks since the technology is not owned, but there is less control and often significant expenses associated with moving data in and out of the cloud.

During this information-gathering process, it became apparent that, while the library lacked resources, we did have one valuable commodity: our patrons' data. We found that several parties were interested in exchanging resources for access to our data. While this may be an answer to the lack of resources, it raises significant concerns about data governance, sharing, privacy, and how the data would be used by those requesting access. This is part of a larger discussion that developed out of this project, questioning the stance of our library about what patron data is collected and how it is stored and used. Currently, we are working to develop a library-wide consensus on this issue through town halls and information sessions involving various stakeholders.

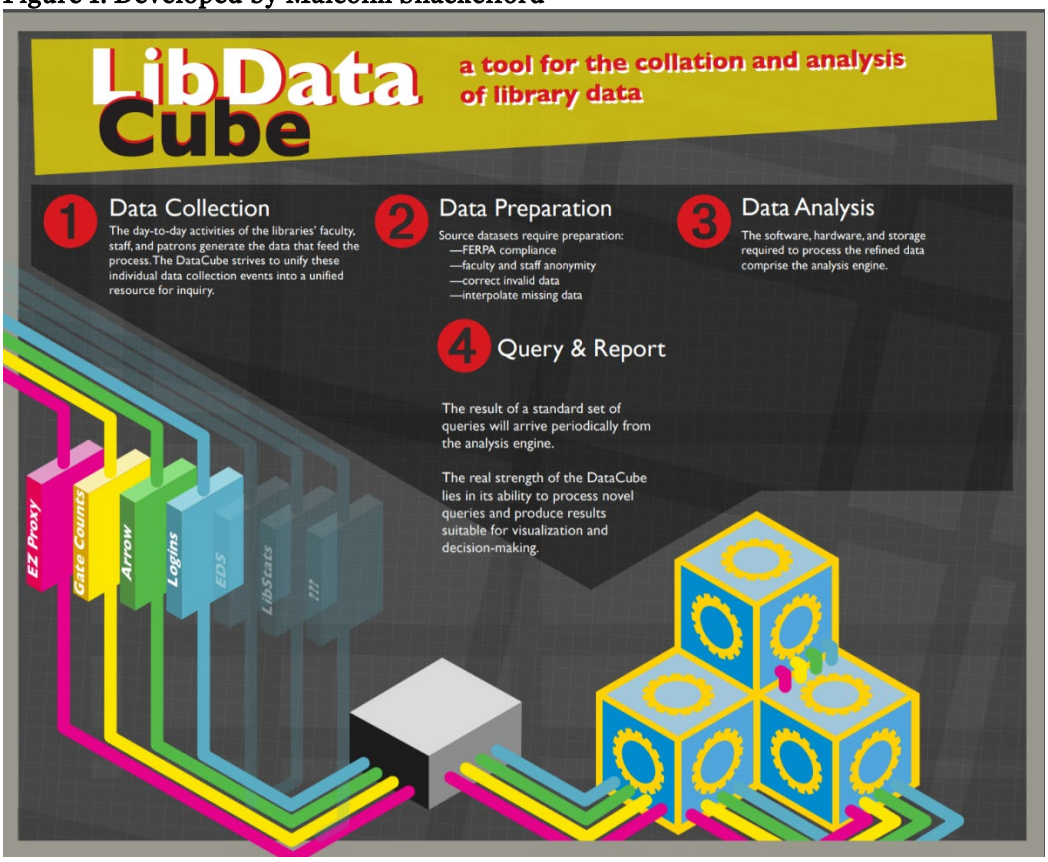
Data Security and Privacy Conversations

We attended two meetings that have been helpful in structuring these discussions with the Office of Institutional Research and the Office of Research Institutional Review Board (IRB). Representatives from both units engaged in conversations with us about consent, ethical research, data collection protocols, data security and storage procedures, retention and archiving policies, and data sharing policies and agreements. Many of these had not been previously discussed within our library and there were no policies or procedures in place to help us deal with these issues. Several working groups were convened to do environmental scans on data governance policies on campus and within academic libraries as well as to review data privacy standards within academic libraries, especially those using or building library cubes.

Developing the Concept

The cube concept is sometimes difficult to describe in a simple and appealing way to engender buy-in from stakeholders who may want to invest in the project. In the first visualization of the cube, we had not even built a master file with more than two datasets, so articulated steps were based on theory and existing documentation of the process (see Figure 1).

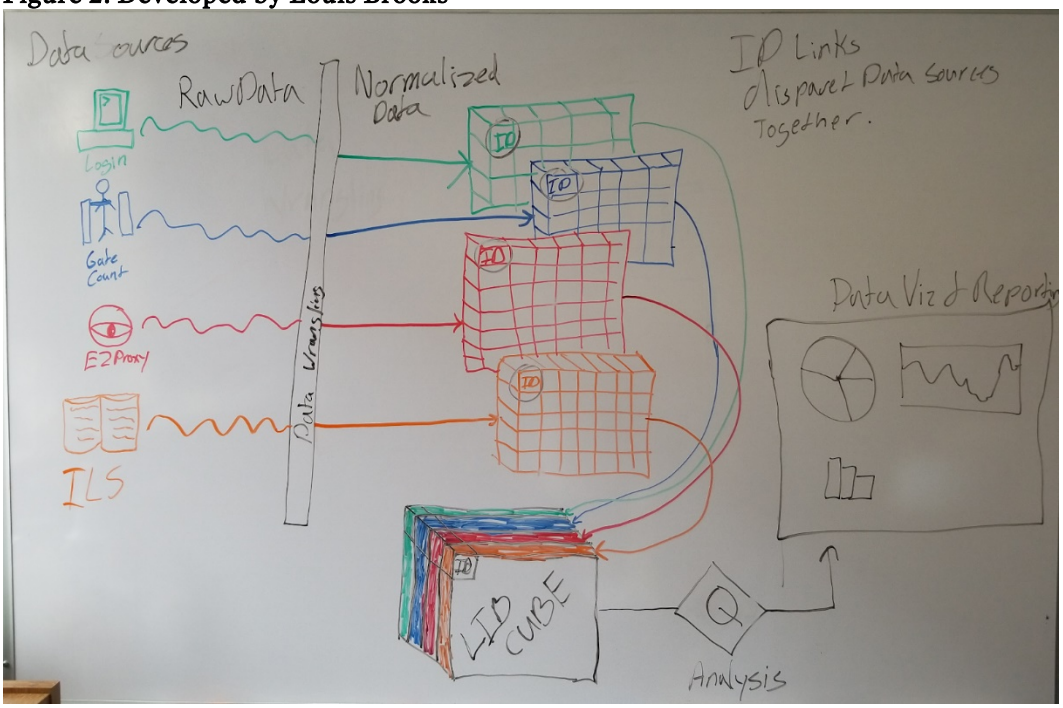
Figure 1. Developed by Malcolm Shackelford



One issue that came up from this design was that proprietary names should not be associated with datasets, such as LabStats, EZProxy, Arrow, EBSCO Discovery Service (EDS), or LibInsight (for example, using e-resource authentication as a description, rather than listing the EZProxy service by name). This would allow us to expand potential content based on theoretical and empirical frameworks that might become useful while exploring data for inclusion into the LibCube.

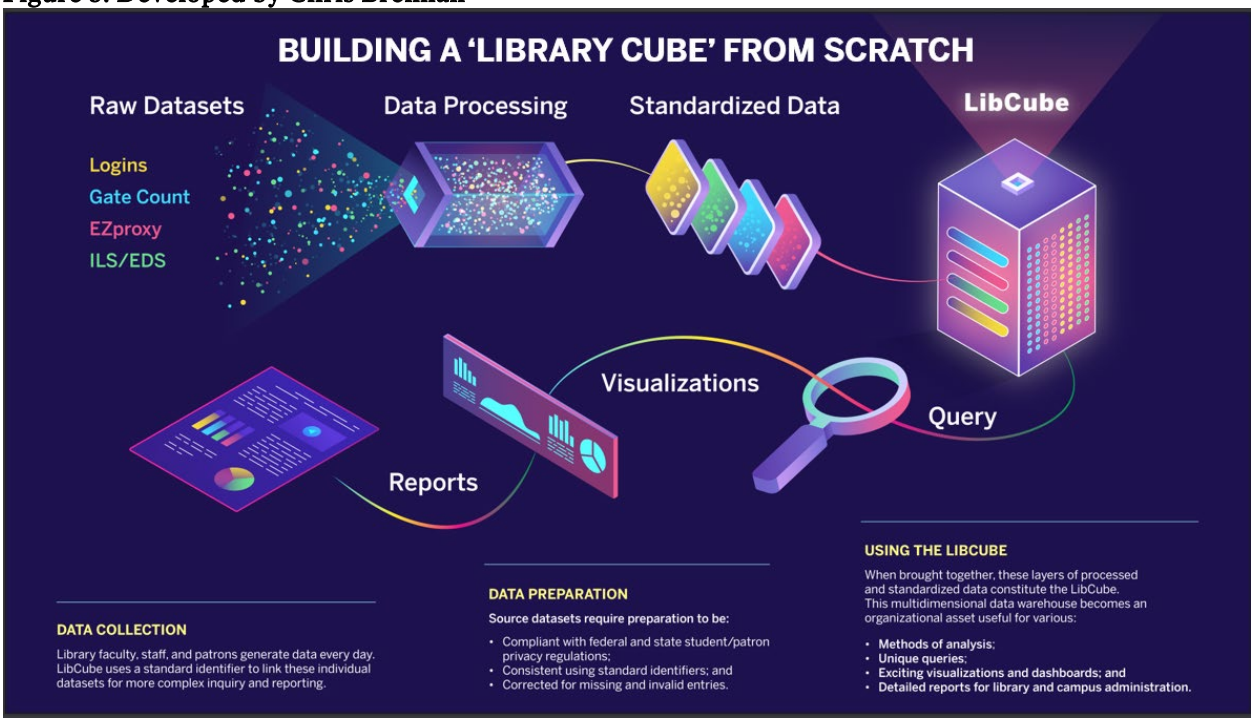
In Figure 2, we developed the previous figure to account for the data management process that is necessary to clean and merge any data before integrating it into the cube. For FSU Libraries, this aspect was most challenging for the turnstiles or gate count data, one of the larger datasets that involves several steps to clean and merge by month. Unfortunately, there have been many problems in cleaning our gate count data because of matching, duplications of swipes and visitors, and determining inclusion or exclusion criteria for staff. Merging this data includes several physical points of entry across two libraries by individual units to get aggregate counts of frequency and duration of library visits. Each dataset comes with its own unique data management challenges, which must occur prior to merging data with unique identifiers—shown more clearly in this rendering:

Figure 2: Developed by Louis Brooks



Expanding on these previous frameworks and from the experience of getting started on cleaning and merging a few datasets, we had a clearer understanding of the process necessary for us to build the LibCube at FSU Libraries. We capture this more thorough process in Figure 3, which includes data collection, data processing, and using the LibCube.

Figure 3: Developed by Chris Brennan



Data Inventory and Creating Community Buy-In

Between the assessment and technology departments, we already had an idea of the datasets we could merge in the LibCube; however, we knew there were many more datasets floating around the library. A team of committed, cross-departmental staff planned and implemented a data inventory across the library to help us understand what data was being collected, why, and where it was being stored. Documentation for the inventory process, including workflows, submission methods, and dictionaries for terms, was made available to everyone and was also emailed to the organization with support from the interim dean. This support from library administration was an important first step for garnering community buy-in and participation. We had a positive response from participants, many of whom thought it was fun to learn more about data in general and to feel like they were data management experts. We cannot overstate how much we learned from this project, not just for LibCube but for the entire organization, including learning what datasets are being collected, how they may be connected to other datasets, duplications of effort, data protections and storage practices, ways to get data out of silos, and how to prioritize and possibly centralize datasets for ease of access. It initiated further conversations about our organizational practices regarding survey creation and data collection, as well as inquiries to library administrators about the types of data and analyses they needed to communicate compelling narratives about the library to stakeholders.

Data Wrangling and Processing

Data Management Best Practices

A project like this one starts with good data management. For example, many of the files merged to form the card swipe/turnstile dataset were not named consistently. Files at various stages of the data cleaning and merging process were spread out over different locations, including flash drives, external hard drives, and a shared internal drive. The data inventory revealed over 140 datasets spread out across the organization, many of which were not subject to good data management practices. Building a culture of data management and finding ways to educate and standardize norms about file naming conventions, storage best practices, and terminology for describing data is a long-term solution. Through internal training and creating content in LibGuides and video tutorials, we have started this journey with our colleagues, but understand that changing organizational culture around these practices takes time and patience.

Choosing a Data Key

To make any library cube work, a major step is choosing a master key or a data point to link all datasets that is low-risk for revealing private or protected information of library users. Many files contain student identifiers, including usernames, card numbers, email addresses, and student or employee identification numbers. At FSU, we found identification numbers called EMPLIDs to be a stable identifier across time assigned to each student and staff. This type of identification number was also used at UOW to join their datasets together. When isolated from other identifiers, these numbers do not reveal information about the individual and can therefore be used to connect data that is easily de-identifiable for further analysis. It is important to keep these concerns for data privacy in mind when deciding on stable identifiers and should be deemed minimal risk to the student as opposed to Social Security numbers, which are high risk and highly protected information. FSU card numbers, the card swipe identifier for gate counts, are unstable because, if a student loses their card, they get a new card with a new number. Therefore, EMPLIDs were a logical choice for the master key and it also connects with student success data using the university's business intelligence software.

Data Collection Technical Issues

There were several technical questions that had to be answered when we started collecting data. What data was to be collected for use in the cube? How was it to be collected? Where was it to be stored and in what format? Who would have access? How would data be moved between each stage of the project? Obviously, the answers for these will depend on your environment and how your IT infrastructure is set up. Initially we identified three sources of data that we wanted to collect to get the project started. These sources were gate count data, computer login data, and e-resource usage. These were all stored in unique systems that were not designed to work together. The gate count data was collected and stored by the University Police

Department. Computer login data was collected using a cloud-based tool called LabStats. E-resource data proved to be the easiest to collect through our proxy server since that was managed internally.

Each data source had a unique method of collection, storage, and transmission. In several instances, getting access to the data proved difficult because the systems were not networked or were controlled by an outside entity. An example of this was the gate count data that we used. As mentioned above, this was controlled by the University Police Department and it took two years of effort to get access in a usable format.

Patron privacy has always been at the forefront of our thoughts when developing this project. While we are only interested in collecting data on cohorts of patrons, not individual patrons, the data collected is at the individual level. This requires limiting who has access to the data and ensuring that it is always secure. Unfortunately, every time you add a data source, you will invariably add people to the group who have access. Our solution was to try to minimize who has access to each individual data set and to further limit access to the complete database to only the authors of this paper and a couple of library administrators. We also set up a central location for all data to be stored. Unfortunately, moving the data to this location is still a very hands-on effort, but we are working on automating the process.

Building the LibCube

Developing Proof of Concept with Prototype

Building on previous literature, we developed the theoretical foundation for the LibCube and sought support from library administration to start with a "baby cube" using several extant datasets, including desktop logins, turnstile data, tutoring data, and student data. These data are like those used in the UOW library cube. We also received feedback from library administration about their end-user expectations for how to work with the data, including a desire for Tableau or Power BI data dashboards that would allow them to interact with real-time, aggregated data. In addition, they expressed a need for easy-to-access querying and reporting using the database for creating reports to use in their campus meetings. These requests helped us further develop the "Using the LibCube" end of the process and to think about the shape of the data that would allow us to meet those expectations.

Technical Data Warehousing Considerations

There are many ways to go about storing large quantities of data, including cloud-based data warehousing, local server data warehousing, local analytical cubes pulling from other files, large workbooks with pivot abilities, and/or large spreadsheets. Each of these options have their own maintenance and technical advantages and disadvantages, all of which we have not fully explored. With the amount of data we currently have, we have been able to manually combine datasets within an Excel worksheet. Although we have not yet decided on our strategy for the data warehouse once we outgrow our current master file method, we have been discussing these options with other campus organizations and academic libraries to determine the best path for our library.

Considering the End User and Accessibility

Different levels of consumption by end-users (i.e., statisticians, IT, library administrators, staff, etc.) influence the shape and technical specifications of a data warehouse, which are also expensive to build, so thinking about these things ahead of time will save an organization time and money. Our current master file approach may be useful for importing data into statistical analysis software; however, as the file grows and we add more data, this method is becoming difficult to maintain and it is difficult to query or use for reporting. Databases are easier to query and create dashboards, which were both important to our administrators. Before we proceeded with building the LibCube, we considered our end-users, the data they will need, and the format in which they will need it. As one can imagine, this line of inquiry easily becomes overwhelming because it further introduces questions and concerns about data governance, privacy, storage, and sharing. Without these organizational policies to guide us, we run the risk of making patron data vulnerable in the process of attempting to make it useful. These and other issues will continue to be grappled with as we move the project forward.

Conclusion

Trends in assessing academic libraries have focused on bringing together diverse sets of measures that reflect many facets of services, spaces, and collections that benefit our campuses and patrons. This, paired with measuring library impact on a spectrum of outcomes—including grades, retention rates, student learning, engagement, and even employability after graduation—shows a greater demand to find data solutions that will allow for this range of inquiry. Now, FSU Libraries seems to be stuck in the merging phase of the building process, with many data management challenges emerging, but we are also engaged in necessary policy conversations. Also, the library data inventory that was completed in fall 2018 will hopefully help us identify what data we have and to assess the gaps in the data sets we still need.

The library's IT department and data services librarians are essential to guiding the process regarding technical and data management issues that are critical to building the cube. Support from library administration is key, though if the goals for the cube are not clearly communicated, especially if the initiative of building the cube is at a grassroots or middle management level, the process moves slowly. At FSU Libraries, the process of tying student measures to card swipe data is not streamlined because card numbers are not stable identifiers and takes a lot of processing to clean, manage, and tie to identification numbers. That is just one data set!

The infrastructure of a cube cannot be built without support from campus partners in institutional research and guidance from university data governance and ethics initiatives. We need to balance the protection of patron privacy with the need for academic libraries to hold themselves accountable as contributors to the success of the university. Mapping the dimensions and measures that LibCube could contribute to demonstrating alignment with the university strategic plan or state performance metrics will guide the development of the cube. We can also learn from the experiences of other campus organizations that are developing their own databases, including the Office of Distance Learning, University Housing, and Campus Reimagined.

We have also connected with other university libraries that have gone through the process of creating similar databases. When we spoke to Jim Stemper, the organizational data strategist at the University of Minnesota Libraries, he described how they created a cube-like database using Microsoft Access that is tied to the campus research office. Titled the Library Data and Student Success project, their research has resulted in many publications and improvements to their libraries' services. Recently, we corresponded with Arizona State University's Mark McCann about EZProxy data gathering and connecting that data with student usage and outcomes—something they are interested in doing at their library. We hope that sharing our experiences through these conversations and proceedings might help other universities and colleges grappling with similar issues and projects.

Notes

1. ACRL, Academic Library Impact on Student Learning and Success.
2. Astin, Assessment for Excellence.
3. ACRL, Value of Academic Libraries; CRL, Academic Library Impact on Student Learning and Success.
4. ACRL, Academic Library Impact on Student Learning and Success.
5. Haddow, "Academic library use and student retention"; Soria, Fransen, and Nackerud, "Library Use and Undergraduate Student Outcomes"; Soria, Fransen, and Nackerud, "Beyond Books"; Soria, Fransen, and Nackerud, "The Impact of Academic Library Resources on Undergraduates' Degree Completion"; Stone and Ramsden, "Library Impact Data Project."
6. Cox and Jantti, "Discovering the Impact of Library Use and Student Performance."
7. Jantti, "Unlocking the value from your library's data.
8. Cox and Jantti, "Discovering the Impact of Library Use and Student Performance."
9. Cox and Jantii, "Discovering the Impact," paragraph 4.
10. Stone and Ramsden, "Library Impact Data Project."
11. Evans and Golian-Lui, "Demonstrating the Library's Contribution Towards Student Retention, Progression and Graduation Rates."
12. Stemper, University of Minnesota Libraries' Organizational Data Strategist, in discussion with the authors, July 2018.
13. Hill, et al., "When in Doubt, Go to the Library," 116–136.
14. Mao and Kinsley, "Embracing the Generalized Propensity Score Method," 129–57.

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