Potatoes to patrons: Using a variation of R. A. Fisher’s agricultural split-plot model to explore patron perceptions of the Information Control dimension of LibQUAL+

Christopher S. Guder

Ohio University

Introduction

As libraries strive to incorporate data-driven decision making into their planning activities, knowledge of statistics and the various methods of analysis employed to make sense of the collected data play an important and essential role in that decision making process. One of the obstacles in this data-driven process is that the method of analysis and the corresponding results are often difficult to understand without a solid foundation in statistics and research design. If the reader of a study does not understand the design or methodology of library research, then the reader has to rely on the opinions of the researcher to formulate strategic decisions about the library. In order for library and information science research to continue to move forward and build upon itself, more librarians need to develop a better understanding of the research designs available to them. This paper attempts to not only deliver the results of study, but also to explain a complicated method of statistical analysis in a way that is more understandable and relatable to the work going on today in academic libraries. The research discussed below was originally conducted as partial fulfillment of doctoral work in the field of Instructional Technology, and while the study and results are abbreviated here, the complete and unabridged dissertation is available online at no cost (Guder, 2012).

The purpose of the original doctoral study was to use a method of analysis that is seldom used in library and information science in order to answer a question related to campus initiatives and their impact on the academic library. The purpose statement or over-arching question revolved around a campus moving from a focus on research activity to a focus on teaching and learning, and what that shift would mean to the academic library. In order to explore this question a three-way between-within subjects ANOVA method of analysis was applied to a sample of the large collection of pre-existing data that is available to libraries though an involvement with the Association of Research Libraries (ARL) and the LibQUAL+ survey. The process and results of this particular type of ANOVA are often difficult to understand, so in an attempt to make the results more understandable, the results will be discussed within the context of the original research model this ANOVA is derived from. From a historical perspective, the explanation for the study and analysis of variation that would become the ANOVA needs to begin with Ronald Aylmer Fisher and his work at the Rothamsted Experimental Station.

R. A. Fisher and the split-plot design

Sir R. A. Fisher was a Cambridge University educated mathematician and physicist who, in 1919, became a member of the Rothamsted Experimental Station and was tasked with analyzing 60 years of accumulated data (Daintith, 2009). The Rothamsted Experimental Station, founded in 1843 as a research facility experimenting with fertilizer, began to also focus on crop studies and animal nutrition in the early twentieth century (Rothamsted, 2015). The large stockpile of data available to Fisher at Rothamsted enabled him to work on new methods of analysis including the analysis of variance (McMurray, 1995), otherwise known as the ANOVA. Fisher’s 1925 work, Statistical Methods for Research Workers, chronicles some of the analyses
he conducted at Rothamsted including the split-plot design which this current study is based upon.

In one of Fisher’s split-plot experiments (Fisher, 1928), he used data collected at the Rothamsted Experimental Station that was initially gathered to study potato yields. In the study, a plot of land was divided into 36 patches, with each patch then subdivided into three lines. There were then 12 different varieties of potatoes grown on these patches, one type of potato per patch, with the result being that each type of potato was represented in three separate patches. Although each patch received a covering of dung, each line within the patch then received an additional dressing of either basal, sulphate, or chloride dressing. This meant that each type of potato was exposed to the three different types of dressing in each patch. The total yield of each potato variety was then recorded in pounds. The results would show if different types of potatoes had different yields, whether the three types of fertilizer dressings made a difference in the yields, and lastly if the dressings make a different amount of difference depending on the type of potato. The image below (Guder, 2012, p. 106) gives a visual representation of the above described experiment. Each patch has a specific type of potato laid out in three rows, and each dotted line represents a row with a different type of dressing labelled s, c, or b (sulfate, chloride, or basal).

![Figure 1. Fisher’s Split-Plot Experiment](image-url)
Methodology of current study

In the experiment above, Fisher is looking to see if there is variation in yield within the patches with regard to dressing, if there is variation in yield between patches that contain the same variety of potato, and finally if there are differences between yields for all varieties of potato. In the current research study being conducted using LibQUAL+ results, the variables are essentially set up the same way, with the major difference being the within-subjects variable.

The first between-subjects variable in the current study was patron-type (or potato variety in the original Fisher model), with the three categories of undergraduate students, graduate students, and faculty members. This separation can be achieved using the demographic information provided by each survey respondent.

The second between-subjects variable in this study was the Carnegie Classification of the institution (type of dressing in Fisher model) which consisted of RU_H or Master’s M categories. According to the Indiana University Center for Postsecondary Research, which is now responsible for the Carnegie Classification of Institutions of Higher Education (Carnegie Foundation for the Advancement of Teaching, 2014), RU_H schools are research universities with high research activity based on per-capita research activity and the level of research activity, and Master’s M schools are Master’s level schools with medium-sized programs with between 100 and 199 degrees awarded (Carnegie Classification of Institutions of Higher Education, Center for Postsecondary Research, n.d.).

Substituting for potato yields in the current study is the within-subjects variable of library service quality as measured on the Information Control (IC) portion of the LibQUAL+ survey. The IC portion of the LibQUAL+ survey has three separate measurements, or levels, which ask the patron what their minimum, perceived, and desired levels of service are. By treating the levels of service quality as measurements taken at three separate times, thus creating a repeated measures or within-subjects variable, the method of analysis in the current study moves from Fisher’s split-plot model to a three-way between-within subjects ANOVA. In the current research design, each level of the IC variable is treated as a measurement taken at a different time, or more specifically, each patron is given three opportunities to receive a score. Each variety of potato receives all different combinations of dressing in the Fisher model, each individual potato does not receive all the treatments. The flow chart in Figure 2 (Guder, 2012, p. 109) shows how the current study differs from the original Fisher experiment by using the same concept of a plot. The plot in Figure 2 is broken up into Carnegie Classifications and Patron types, instead of potato varieties and dressings.
The Information Control component of LibQUAL+ was chosen for this study over the other two components, Affect of Service and Library as Place, because of the strong connection the IC portion of the survey has to technology. The current study was meant to build on the idea that the library serves as an “electronic hub” (Guthrie and Housewright, 2011, p. 86) for patrons and that our library catalogs should be considered more like a “sphere of access” (Holden, 2010, p. 33) in that libraries should connect people and materials, regardless of whether they are housed in or even owned by the library. Both of these concepts seem very much in line with the Information Control component of LibQUAL+. Technology plays a pivotal role in the locating and retrieval of material in the modern library collection. Full-text articles paid for by the library are accessible through the library databases, government documents freely available online are linked and discoverable in the OPAC, print materials are scanned and made available electronically through InterLibrary Loan, and print materials are physically made available via an electronic request form and a strong consortial library delivery system. Ease of independent use, access from outside the library, and library website design that enables individuals to use resources, are all questions being asked in the IC component of LibQUAL+, and all have a direct relationship to technology decisions made by libraries.

In much the same way that Fisher was using pre-existing data to conduct his variance experiments, the current research project was also conducted on a pre-existing dataset that consisted of LibQUAL+ results from two separate university libraries representing two different types of campuses. The study hoped to explore the relationship, if any, between patron-type, Carnegie Classification, and the results of Information Control component of the LibQUAL+ survey. The three-way between-within subjects ANOVA, using the variables of Carnegie
Classification, patron-type, and Information Control scores for minimum, perceived, and desired levels of service, enables the following seven research questions to be asked:

1. Are there significant differences between the minimum, perceived, and desired scores for library service quality?
2. Are there significant differences between the levels of Carnegie Classification with respect to the minimum, perceived, and desired scores for library service quality?
3. Are there significant differences between the levels of the respondent group with respect to the minimum, perceived, and desired scores for library service quality?
4. Is there a significant interaction between the Carnegie Classification of an institution and the level of respondent?
5. Is there a significant interaction between the Carnegie Classification of an institution and the minimum, perceived, and desired scores for library service quality?
6. Is there a significant interaction between the level of respondent group and minimum, perceived, and desired scores for library service quality?
7. Is there a significant interaction between the level of respondent group and the Carnegie Classification of an institution and the minimum, perceived, and desired scores for library service quality?

A random-stratified sample was used on the RU_H campus, and a saturation sample was used on the Master’s M campus. A power analysis was conducted using G*Power and it was determined that there was adequate power to proceed with a power of .95 to detect a small effect size of .05. An assumption of this particular ANOVA is the assumption of sphericity. Mauchly’s sphericity test was run, see Table 1 below, and a violation was detected, so Huynh-Feldt corrections were used in the analysis. The data screening techniques used by ARL on the LibQUAL+ results were also used in this current study, so only the results listed as complete and active by LibQUAL were used in the analysis. Box plots, stem and leaf displays, and histograms were used to study outliers and it was determined that while there were some extreme scores they should be included.

Table 1.

*Mauchly’s Test of Sphericity*

<table>
<thead>
<tr>
<th>Within Subjects Effect</th>
<th>Mauchly’s W</th>
<th>Approx. Chi-Square</th>
<th>df</th>
<th>Sig.</th>
<th>Epsilonᵇ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information Control</td>
<td>.833</td>
<td>150.507</td>
<td>2</td>
<td>.000</td>
<td>.857</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.864</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.500</td>
</tr>
</tbody>
</table>
Results/Findings

As demonstrated in the tables below, three of the research questions showed significant findings at the pre-determined significance level of p = .05. The first is that there are significant differences between the recorded minimum, desired, and perceived scores for library service quality as recorded on the Information Control component of LibQUAL+, as shown with a p = .000 and a partial eta squared of .060. The second significant finding involves patron type and the LibQUAL+ scores. A p = .002 with a partial eta squared of .015 indicates that there are significant differences in the way undergraduates, graduate students, and faculty answered the Information Control component of LibQUAL+. The third significant finding also deals with patron type and Information Control scores, showing that with a p = .001 and a partial eta squared of .012, the Information Control scores are not only different for the patron types, but also that the scores change with regard to the different levels of Information Control scores as well.

Table 2.

Tests of Within-Subjects Effects (Huynh-Feldt)

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC</td>
<td>110.711</td>
<td>1.728</td>
<td>64.068</td>
<td>52.834</td>
<td>.000</td>
<td>.060</td>
</tr>
<tr>
<td>IC * Carnegie Class</td>
<td>3.277</td>
<td>1.728</td>
<td>1.897</td>
<td>1.564</td>
<td>.212</td>
<td>.002</td>
</tr>
<tr>
<td>IC * UGroup</td>
<td>21.537</td>
<td>3.456</td>
<td>6.232</td>
<td>5.139</td>
<td>.001</td>
<td>.012</td>
</tr>
<tr>
<td>IC * CC * UGroup</td>
<td>2.249</td>
<td>3.456</td>
<td>.651</td>
<td>.537</td>
<td>.683</td>
<td>.001</td>
</tr>
<tr>
<td>Error(IC)</td>
<td>1732.934</td>
<td>1429.074</td>
<td>1.213</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3.

Tests of Between-Subjects Effects

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>35350.087</td>
<td>1</td>
<td>35350.087</td>
<td>9341.034</td>
<td>.000</td>
<td>.919</td>
</tr>
<tr>
<td>Carnegie Class</td>
<td>11.553</td>
<td>1</td>
<td>11.553</td>
<td>3.053</td>
<td>.081</td>
<td>.004</td>
</tr>
<tr>
<td>UGroup</td>
<td>47.575</td>
<td>2</td>
<td>23.787</td>
<td>6.286</td>
<td>.002</td>
<td>.015</td>
</tr>
<tr>
<td>Carnegie Class * UGroup</td>
<td>15.348</td>
<td>2</td>
<td>7.674</td>
<td>2.028</td>
<td>.132</td>
<td>.005</td>
</tr>
<tr>
<td>Error</td>
<td>3129.688</td>
<td>827</td>
<td>3.784</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

At this point it may be beneficial to go back to the original Fisher study to gain some perspective. Even if concepts like random and stratified samples, sphericity, interaction, significance, and effect size are difficult to grasp, the basic concept of the ANOVA is to see if there are differences in the group means. So instead of different types of potatoes, there are different types of patrons, and instead of different types of fertilizer dressings, there are different types of campuses. These groups all have mean scores attributed to them based on how they answered the LibQUAL+ questions, in the same way that Fisher’s potatoes had yields associated with them. The tables above reveal whether or not there is a significant difference in the group means.

Conclusion/Discussion

The results pertaining to the differences in satisfaction levels across patron types are nothing new and merely add to the research already published in this area (Jaggars, Jaggars, & Duffy, 2009; Kayongo & Jones, 2008; Self, 2008; Wei, Thompson, & Cook, 2005). Undergraduate students, graduate students, and faculty have different opinions regarding the services that libraries provide, and those differences differ depending on the level of IC being discussed.

The results of this study that pertain to Carnegie Classification are a little more difficult to interpret. This study is able to say that, given the responses on one particular survey distributed on two separate campuses, that those two campuses did not show a significant difference in the way they answered the questions. It is important to note however that while the results were not significant in a statistical sense of p < .05, they were relatively close with a p = .08. This finding is misleading because while not significant, a p=.08 is very close to .05 and is definitely a finding
that could be actionable with regard to library policy and planning. If only significant findings are documented in the results of a study, and the reader doesn’t know how to read the tables, a non-significant but important finding could be ignored. The study described above should be repeated using Carnegie Classifications that are further apart, or perhaps a third type of Carnegie Classification like a community college should be added to make that variable have three levels. The addition of a third CC type may produce enough variance to show a significant finding with regard to Carnegie Classification and Information Control scores.

Perhaps more important than the findings in this particular study is the attempt to incorporate complex methods of analysis on large datasets by libraries. As libraries continue to collect data in order to demonstrate value both internally and to external audiences, librarians and decision makers will find it useful to incorporate a broader range of research designs to make sense of the data they are collecting. The beauty of the method of analysis described in the study above is not only that it can be explained and taught from a historical perspective, but also that it could easily be reorganized to study other variables of interest to individual libraries. Any of the three components in LibQUAL+ for example can be used as the within-subjects variable, but program or major could be substituted for Carnegie Classification, or gender for patron-type, depending on the research question being explored. LibQUAL results contain large quantities of information and the three-way between-within subjects ANOVA is an excellent tool to help analyze and create meaning from those results.

References


