Evidence Based Library and Information Practice

Feature Article

Identifying Appropriate Quantitative Study Designs for Library Research

Diane Lorenzetti
Centre for Health and Policy Studies
University of Calgary
Calgary, Alberta, Canada
E-mail: dllorenz@ucalgary.ca

Abstract

This paper is concerned with the identification of quantitative study designs suitable for library research. Identifying a researchable question and selecting a research method best suited to it are key to the successful design and execution of any research project. Each research situation is unique, and each researcher must find the method that best suits both their situation and the question at hand. Following a brief discussion of issues related to question development, the author outlines a checklist that may assist the process of selecting study designs for quantitative research projects. When faced with options in terms of study design selection, pragmatic issues such as expertise, funding, time, and access to participants may influence this decision-making process.

Introduction
Identifying a researchable question and selecting a research method best suited to it are two important decisions that any investigator must make when embarking on a research project. It is these processes with which this paper is concerned.

After a preliminary discussion of question development, this paper attempts to shed some light on research design selection by introducing a means by which researchers can match their questions to a selection of appropriate study designs. The focus of this paper will be on quantitative research.

What is quantitative research?
Research designs may be qualitative, quantitative, or mixed methods techniques

which employ both qualitative and quantitative methods.

Qualitative research focuses on exploring the views of individuals. "Observing events from the perspectives of those involved" (Powell and Connaway 3) is used as a means to develop theories to explain events or behavior (Creswell, Educational Research; Powell and Connaway). Because a qualitative research approach is exploratory, it is often used when a topic is new or little understood, or where "existing theories do not apply" (Creswell, Research Design 22).

Quantitative research, on the other hand, is primarily concerned with testing theories and measuring the relationships between variables or the impact these variables have on outcomes of interest (Couchman and Dawson; Creswell, Educational Research). Whereas qualitative researchers use events and individual experiences as a way of developing theories, quantitative researchers begin with a hypothesis or theory and then try to prove or disprove it. Generally speaking, a quantitative approach might be recommended if a research project involves the identification of "factors that influence an outcome, the utility of an intervention or understanding the best predictors of outcomes" (Creswell, Research Design 21-22). Within this broad category are a variety of research designs, including surveys, bibliometrics, and experimental designs or techniques.

Experimental techniques is a category of quantitative research design wherein the researcher attempts to determine the impact of an intervention (e.g., a teaching technique, electronic database, or collection development policy) on an outcome or effect of interest. An example of an experimental design is a randomised controlled trial. In experimental research, investigators are interested in exploring issues of "cause and effect" (Creswell, Educational Research 283).

An investigation into whether or not researchers who receive training in literature searching skills are more successful in obtaining funding from granting agencies than those who do not is an example of a research problem that could be answered through an experimental research design. Here, the intervention is the training and the outcome or effect is the number of successful grant applications.

True experimental designs are those in which research participants can be randomly allocated to receive or not receive an intervention of interest. Quasi-experimental designs are experiments in which researchers, for whatever reason, are not able to randomly assign participants and, instead, conduct research with naturally occurring groups - for example, students registered in an introductory political science course (Creswell, Educational Research).

Developing a researchable question
Before tackling the demanding task of launching a research project, we should ask ourselves the following question: What do we want to know?

In a survey published in a 2001 issue of *Hypothesis*, medical librarians were asked to "identify the most relevant research questions currently facing the profession" (Evidence Based Librarianship Implementation Committee 9). The variety and complexity of these responses clearly indicates that the profession continues to grapple with many challenges. Among other things, we are concerned with issues of resource selection, budgeting, library skills training, the adoption of new technologies, and the need to determine what impact our profession has on the clients we serve (Evidence Based Librarianship Implementation Committee). There appears to be no lack of potentially researchable issues of interest to our profession.

An awareness of a given topic and its potential options or issues provides researchers with the information they need to decide on the scope and direction of their research. Those unfamiliar with aspects of a given topic will find it useful to explore their area of interest prior to developing their research questions. A literature review may identify whether or not research already exists in librarianship or a related field. Conducting quality original research can be time consuming. It may be that adequate evidence already exists that can be adapted to your needs.

The importance of developing specific questions that accurately reflect research needs cannot be overstated.

Background versus foreground questions
Questions may be loosely grouped into two types: background and foreground. When you need to gather together basic underlying background knowledge on a topic, you are dealing with a background question (Booth; Richardson and Wilson). In addressing a background question, you attempt to arrive at a greater understanding of the complexity and diversity of the literature as a whole, either as an endpoint in itself or as a first step towards developing a more focused foreground question. An example of a background question might be: "What online systems exist to facilitate the delivery of distance education courses?"

Now imagine that you have identified through research that Blackboard (an online tool that allows students and instructors to communicate over the Internet) may be an effective tool for the delivery of distance education courses in your institution. You would like to determine if it would be effective by comparing Blackboard to your existing method for online course delivery. A foreground question is very focused in its research aim. It contains multiple components, which are clear and can be

clearly stated (Booth; Richardson and Wilson). An example of a foreground question might be: "Is Blackboard an effective tool for online library literacy course delivery?"

PICO is a model that can help facilitate the development of a researchable question.

PICO stands for:
P population
I intervention(s) or exposure
C comparison
O outcome(s) of interest

- *Population* is the group under observation/study (in the case of collection use studies, the population could well be the library's collection of books, journals, or other media)

- *Intervention/Exposure* is the action or intervention of interest

- *Comparison* is an alternative action or intervention against which the intervention of interest will be measured.

- *Outcome* is a measure of the desired effect of the Intervention/Exposure

Although PICO was developed as a clinical model, it can be adapted to other disciplines of research, including librarianship.

So why use PICO? Identifying the PICO or building blocks of a question/problem can identify gaps in question development and may inspire investigators to rethink and/or reevaluate an original premise, making for a solid researchable question.

Using the PICO model may also point the way towards specific research designs amenable to particular types of questions of which yours is but one. For instance, if it appears that you will be comparing one intervention to another, this identifies your

question as belonging to a family of questions which can be effectively researched by employing a certain type of quantitative study design. On the other hand, if it appears that the research question properly belongs to that category previously identified as a background question, this too is valuable information that may inform the choice of research design.

So how can this be used? Imagine we are evaluating the reference services we offer to students. We would like to know if an in-person, drop-in reference service would absorb more or less librarian time than an email reference service.

If we apply the PICO model, the components of this question might be identified in this way:

Population: students
Intervention/Exposure: in-person drop-in reference service
Comparison: email reference service
Outcome: frequency of use

The research question that results from this exercise could be:

Would an in-person drop-in reference service be used more frequently by students than an email library reference service?

Although this example fits neatly into the PICO format, in many instances no comparison exists in which case "No Intervention/Exposure" (or placebo) is the comparison.

Rarely are questions born in their final format – they almost always require some tweaking. At this point you might decide to re-evaluate your question to focus on any other outcomes of interest (e.g., amount of time spent responding to each request) or populations (e.g., university faculty in

addition to students or perhaps some subset of the student population).

Identifying the research method
Once a researchable question has been identified, the next step is to match it to an appropriate research design. Each design has its own strengths and weaknesses. While some may be ideal for tracking trends, others are better at demonstrating cause and effect or predicting outcomes. The nature of a research question should guide the design selection. At the same time, there may be more than one research design that could be appropriate for your project. As with question development research design selection can be, in some instances, an iterative process.

In a 2002 article on levels of evidence in evidence based librarianship, Eldredge identified three categories of research questions: prediction, intervention and exploration ("EBL levels of evidence"). Prediction questions anticipate outcomes; intervention questions compare actions or processes; and exploration questions may be equated with background questions in that they often describe or synthesize observations or results (Booth; Eldredge "EBL levels of evidence"). Eldredge organized specific research designs according to their appropriateness for answering one of these three question types ("EBL levels of evidence"). This paper was used as the basis for developing the checklist that follows for the selection of quantitative research designs.

Using the checklist, librarians new to the field of research may identify possible research designs based on the focus or goal of the question under consideration. Consider, in general terms, what you hope to achieve through your research. Determine which of the activities and corresponding study designs is conducive to the aims or goals of your research.

You may find that more than one research design fits your needs. When deciding on an approach, consider not only the suitability of the research design but the expertise, resources, time and other variables that will be integral to the successful completion of this piece of research. In other words, what resources will you need in order to research your question in the manner you have determined to be the most effective? If those resources are not available, a different design may need to be selected.

Descriptions of Research Designs

Bibliometrics
Bibliometrics is a method for describing patterns of publication within a body of literature. It has been used in librarianship to identify core literatures, classify literatures, predict publishing trends, describe patterns of book use, and chart the dissemination of ideas (Powell and Connaway 63).

Checklist for Selecting a Quantitative Study Design from Eldredge, "EBL Levels of Evidence"
Match the desired aims of your research activity to one or more of the activities and corresponding research designs outlined below. Descriptions of the research designs follow the checklist.

Report on observations and analyze experiences with a process, service, program, technology or individual: ☐ Case Study (aka Case Report)

Identify trends in attitudes, behaviors or characteristics where:
 	
Participants will be surveyed at one moment in time
      ☐ Cross Sectional Survey
 	
Participants will be surveyed at multiple points in time
      ☐Longitudinal Survey

Identify patterns of publication within a given field or body of literature: ☐ Bibliometrics/Citation Analysis

Predict whether the presence or absence of an exposure or event influences an outcome of interest where:
 	
Participants will be observed from just prior to the exposure into the future
      ☐ Prospective Cohort Study
 	
Participants will be identified from historical records and followed into the present
      ☐ Retrospective Cohort Study

Demonstrate if the presence or absence of an intervention, service, or process causes an outcome of interest. Here the investigator will attempt to test the strength of cause and effect relationships where:

No comparison/control group is available and the intervention group will act as its own comparison via before and after tests
    ☐ Single Group Controlled Comparison Study
 	
Participants cannot be randomly assigned to intervention or comparison/control groups and pre-existing groups must be used
    ☐ Controlled Comparison Study
 	
Participants can be randomly assigned to intervention or comparison/control groups
    ☐ Randomized Controlled Trial
 	
Participants may be followed over time and multiple observations (pre-intervention, during the intervention, and post-intervention) may be made
    ☐ Time Series

Map key concepts and/or identify gaps in a research area: ☐ Scoping review
Evaluate existing published evidence with respect to a specific research question: ☐ Systematic Review
Pool or combine the results of published studies to determine a measure of effectiveness: ☐ Meta-analysis
Calculate the probability of expected consequences of implementing different strategies: ☐ Decision Analysis

Citation analysis is a form of bibliometrics in that it focuses on identifying patterns of citation (Powell and Connaway 63). Citation analysis can be used to identify seminal studies in fields of research, trace the citation history of studies, or identify influential writers within a field of research.

For more information on bibliometrics, readers are advised to consult Powell and Connaway's <u>Basic Research Methods for Librarians</u>.

Case Study
Although case studies/case reports rank low on most evidence hierarchies, they employ few resources, are relatively easy to undertake, and for these reasons, are often the first layer of evidence published with respect to emerging questions, issues, or techniques. Eldredge reported in 2004 that case studies ranked with surveys and qualitative methods as one of the three most used research designs in librarianship ("EBL: an overview" 294). Case studies are a means of reporting on in depth observations and explorations of an individual, population, process, technology, or service (The Cochrane Collaboration Secretariat; Creswell, <u>Research Design</u> 15; Eldredge, "Inventory"; Fraenkel and Wallen). No baseline information is collected and no comparison groups are used. For these reasons, case studies are not capable of proving cause and effect … although they can begin the chain of evidence that leads to a realization of why or how something happens (Eldredge, "Inventory").

Citation Analysis - See Bibliometrics

Cohort Study
A cohort is a population of individuals who share a characteristic (Ruane 99). In a cohort study a naturally occurring group (the cohort) is followed over time it is exposed or not exposed to a particular event. The outcomes of exposed or non exposed members of the cohort are compared (Eldredge, "Cohort studies"; The Cochrane Collaboration Secretariat). A cohort study is an observational study and researchers do not manipulate the cohort in any way. They simply observe the course of events in an attempt to predict whether or not there may be a relationship between the event and an outcome or outcomes of interest (Streiner and Norman). For this reason, cohort studies are sometimes referred to as event-based designs (Ruane). *Prospective cohort studies* follow participants "into the future" (The Cochrane Collaboration Secretariat 8); whereas *retrospective or historical cohort studies* identify participants "from historical records and follow them from the time of those records into the present" (The Cochrane Collaboration Secretariat 8).

For more information on cohort designs, particularly as they relate to librarianship, readers are advised to consult Eldredge's 2002 article on this topic ("Cohort studies").

Controlled Comparison Study
In controlled comparison studies, two groups are compared (Eldredge, "EBL:an overview" 295). Comparisons are made between an intervention group receiving intervention A and a comparison /control group B receiving either intervention B or no intervention (Fraenkel and Wallen 273). The aim is to determine if these interventions (e.g., two different instructional techniques) have an effect on an outcome of interest (e.g., knowledge retention, course grades, etc…). Participants are not randomised to either group. Instead, controlled comparison studies attempt to reduce bias (the chance that observed

outcomes will reflect, for example, differences in the makeup of the two groups rather than differences in the interventions) by attempting to closely match characteristics of participants in the intervention and comparison/control groups (Eldredge, "EBL: an overview" 295). In the case of the instructional techniques example, we might want to ensure that members of both groups are in the same year and program of study, are comparable in age and background, and have had similar past exposure to library instruction. Conducting both pre-tests and post-tests also helps account for variations in these naturally occurring groups. Controlled comparison studies are referred to as a type of quasi-experimental design.

For more information on controlled comparison studies, readers are advised to consult Creswell's <u>Educational Research Methods</u> and Powell and Connaway's <u>Basic Research Methods for Librarians</u> both of which contain detailed chapters on experimental and quasi-experimental designs.

Cross sectional Survey - See Survey

Decision Analysis
Decision analysis is a transparent decision making method wherein all options and possible consequences of each choice are made explicit. It "involves identifying all available alternatives and estimating the probabilities of [and assigning values to] potential outcomes associated with each alternative (Evidence Based Medicine Working Group 409). Existing research and data are used to develop the model and options, and the potential results of those options are represented graphically as a decision tree. Researchers use the probability and value of all outcomes to develop a "quantitative estimate of the relative merit of [each alternative]" (Evidence-Based Medicine Working Group).

For more information, readers are advised to consult Keeney's overview on this topic.

Longitudinal survey - See Survey

Meta-analysis
Meta-analysis is the "use of statistical techniques in a systematic review to integrate the results of included studies" (The Cochrane Collaboration Secretariat 25). By statistically pooling the results of multiple studies, it is possible to determine, with greater certainty, the effect or non-effect that an intervention has on an outcome of interest (Egger, Smith, and Altman; Powell and Connaway).

Although all meta-analyses should begin with a systematic review, not all systematic reviews do or should include a meta-analysis. Although it is possible to conduct a meta-analysis with as few as two studies, a misleading conclusion can result if researchers attempt to combine the results of different study designs (e.g., RCTs and cohort studies) or include data that is not comparable.

For more information on meta-analysis techniques, readers are advised to consult Systematic Reviews in Health Care: Meta-Analysis in Context.

Prospective Cohort Study - See Cohort study

Randomised Controlled Trial
A randomised controlled trial (RCT) is "an experiment in which two or more interventions…are compared by being randomly allocated to participants" (The Cochrane Collaboration Secretariat 37). The intervention group receives the intervention of interest to the researchers and the comparison/control group receives either no intervention (ie placebo) or an alternate intervention (Creswell, Educational Research 295). The ability to randomise participants eliminates many of the

opportunities for bias that exist in other research designs. That being said, it is not always possible or appropriate to randomise participants. For instance, imagine that your library has a subscription to a particular electronic database. It is expensive and you are wondering if it is worth retaining. It may be difficult (not to mention unethical) to randomise students to either have or not have access to a database or other service for which there is already system-wide access. On the other hand, the benefits of email versus in-person reference service, one process of handling document delivery requests versus another, one-time versus multiple follow-up library instruction training, etc … may be successfully explored through an RCT design (Eldredge, "The RCT design").

For more information on RCT design and application, readers are advised to consult Eldrege's 2003 article on this subject (Eldredge, "The RCT design"), Powell and Connaway's Basic Research Methods for Librarians, and Creswell's Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research.

Retrospective Cohort Study - See Cohort Study

Scoping Review
A scoping review is similar to a systematic review in that it employs rigorous methods to rapidly yet systematically locate and review literature appropriate to the research question under review. Unlike systematic reviews though, scoping reviews tend to address broader, less focused questions, include a variety of study designs, and tend to not assess the quality of included studies (Arksey and O'Malley). Scoping studies are often undertaken to map key concepts in a research area and/or identify gaps in the existing literature. They can be used to quickly chart complex areas of research, provide a visual picture of the range of a

field, and are also useful in identifying topics where further research might be warranted.

For more information on scoping reviews, readers are advised to consult Arksey and O'Malley's article on this topic as it provides both an overview and detailed method for proceeding with this type of review.

Single Group Controlled Comparison Study
A single group controlled comparison study (also known as a single group pretest posttest design) is a controlled comparison study wherein only one group is under observation by researchers. The group is measured or observed both before and after exposure to the intervention of interest. Unlike other controlled comparison studies, the intervention group acts as its own comparison or control (Creswell, Research Design; Creswell, Educational Research; Fraenkel and Wallen; Powell and Connaway).

Survey
Surveys are "questionnaires administered to a sample of a population in order to identify trends in attitudes, opinions, behaviors or characteristics" (Creswell, Educational Research 52). *Cross sectional surveys* or studies are referred to as snapshots because they essentially capture information from a group of respondents at one moment in time and are useful for describing current situations and conditions (Ruane 93). *Longitudinal surveys*, on the other hand, gather information at multiple points in time and may be used to track changes in values, opinions, attitudes, and behaviors (Ruane 95). Longitudinal surveys may repeatedly collect information from the same individuals or generate new survey samples each time the survey is administered (Creswell, Research Design; Fraenkel and Wallen; Ruane). A checklist for designing a survey method can be found in Creswell's Research Design: Qualitative,

Quantitative, and Mixed Methods Approaches (155).

For more information on survey designs, readers are advised to consult Fraenkel and Wallen's How to Evaluate Research Design in Education.

Systematic Review
A systematic review is "a review of the evidence on a clearly formulated question that uses systematic, explicit [and reproducible] methods to identify, select and critically appraise relevant primary [original] research, and to extract and analyze data from the studies that are included in the review" (Centre for Reviews and Dissemination 4). Unlike traditional narrative reviews, systematic reviews are comprehensive, unbiased, and systematic in the ways in which literature is located, selected, abstracted, and reported.

For an excellent overview of the process of conducting systematic reviews, readers are advised to consult the 2001 report produced by the University of York's Centre for Reviews and Dissemination entitled Undertaking Systematic Reviews of Research on Effectiveness.

Time Series
Controlled comparison studies and randomised controlled trial designs assume that the researcher will observe/measure participants at a single point in time (twice if a pre-test is included in the research design). If you are able to observe participants over a period of time, you may wish to consider a randomised or non-randomised time series approach. In a time series, multiple pre-test and post-test measures or observations are taken both before and after the intervention (Creswell, Educational Research; Polit, Tatano-Beck, and Hungler 177). The strength of the time series design is in its ability to track the impact of an intervention over time.

Discussion

In a statement released in 2001, the Special Libraries Association (SLA) commented that "both the need to make decisions quickly and the lack of a clear connection between much library and information science research and the day-to-day problems faced by librarians make seeking and applying our own knowledge base a challenge." Although it may be argued that librarians continue to experience a certain lack of professional support with respect to engaging in research activities, we cannot claim to be the only profession that is beset with tight timelines when it comes to making and implementing decisions.

For those of us not schooled in research methods however, undertaking a research project of any sort may appear to be a very intimidating experience. Certainly a brief overview article of this sort will, at best, only whet the appetite for more information. Although there is much that can and should be read on this subject before embarking on a research project, it is often in the application that we learn the most.

Partnering with an experienced professional colleague may be the best way for a budding researcher to become familiar with the research process. If this is not an option, we may wish to consider looking a bit further afield. Many granting agencies look favorably on proposals submitted by multidisciplinary teams. Librarians have skills that make them valuable partners in a variety of research endeavors. Those of us who work in academic libraries are surrounded by research faculty experienced in leading multifaceted research investigations, some of whom may be open to mentoring a beginning researcher in exchange for active participation on their teams.

Insofar as research designs are concerned, the author wishes to reiterate that many questions may be more effectively addressed through qualitative research techniques, and these approaches should be considered when choosing an appropriate design. For a discussion of qualitative research designs in librarianship, readers are advised to consult Eldredge's 2004 inventory of research designs (Eldredge, "Inventory") and Powell and Connaway's Basic Research Methods for Librarians. Many researchers are also embracing the need to incorporate both qualitative and quantitative methods in their research projects (Creswell, Research Design).

Conclusion

This paper has touched on the subject of research design in only the most cursory sense. No attempt has been made to comprehensively represent the range of research designs that exist and may be applied or adapted to answering all questions facing our profession. Readers are encouraged to "research" the process more thoroughly, and speak with colleagues before proceeding to engage in a research endeavor.

Although the focus of this paper has been on select quantitative techniques, it is not the intention of the author to recommend the application of one study design or group of designs over another in all research situations. Not every question can or should be answered by a randomised controlled trial. Each research situation is unique, and each researcher must find the method that best suits both their situation and the question at hand. When faced with options in terms of study design selection, it may be that pragmatic issues such as professional expertise, time, and access to participants will influence the decision-making process.

Sometimes the ideal study design from a research question perspective is not ideal from a practical standpoint; an important characteristic of a researcher should be the

ability to recognize and creatively adapt to the challenges of reality.

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