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Research Design in Library and Information Science

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ABSTRACT

Research design is the bedrock or roadmap of any research work which is anticipated to provide suitable framework on how a study is to be conducted. This design should be carefully prepared prior to the commencement of the research. The type of identified research problem will determine the research design and not vice-versa. Also, the questions to be answered by conducting the research constitute the most important element of any research design. In accordance to literature, the most predominant designs used in Library and information Science (LIS) researches are: Case study, Survey and Experimental designs. This study explained in details these three common designs in LIS in terms of when to be used and how it is been designed. Therefore, it is crucial for LIS researchers to understand these designs in order to always use effective, appropriate and achievable research designs.
Keywords: Research Design, Library and Information Science, Case study, Survey and Experimental Designs.

Introduction

Research design is the framework of research methods and techniques chosen by a researcher.

It can also be described as the structure or master plan of any research work which is intended to provide an appropriate framework for a study or throws light on how the study is to be conducted. Research design stands for advance planning of the methods to be adopted for collecting the relevant data and the techniques to be used in the analysis, keeping in view the objective of the research and the audibility of staff, time and money (McNabb, 2010). Therefore, it is important that an effective, appropriate and achievable research design must be prepared before commencing the research. Research design according to Ahuja (2010) can be considered as the structure of research, he further retreated it as the "Glue" that holds all of the elements in a

research project together, in short it is a plan of the proposed research work. It (research design) is a general plan about what the researcher intends to do to answer the research question. Research design also depicts the type of research be it experimental, survey, case-study, cohort, longitudinal and so on.

The type of research problem identified will determine the research design and not vice-versa. For instance, in a study, research design may reflect the entire research process, from identifying/conceptualizing a problem to the literature review (which reveals what has been done and the gap), research questions (focusing on the research problems in form of questions to be answered), methods (techniques to be adopted in the collection of data), and conclusions. Research design helps in taking decisions regarding what, where, when, how, by what means concerning an inquiry. Research design is not associated to any particular technique of data collection or any particular type of data. Identifying a suitable research design for a study is highly important because it highlights and communicates information about key features of the study, which can differ for qualitative, quantitative, and mixed methods. Therefore, when designing research it is necessary that we recognize the types of evidence required to answer the research question in an appropriate way.

A Critical Factor: Research Questions

Research questions constitute the most important element of any research design. It is to answer them that the research activities are directed. The formulation of research questions is the real starting point in the preparation of a research design. These questions are indispensable and need to be stated clearly and concisely. They can be reduced to three main types: “what”, “why”, and “how” questions. It is important to distinguish between these types of questions as they are related to different research purposes. In general, “what” questions inquire about descriptions, “why” questions seek explanations or understanding, and “how” questions are concerned with interventions to bring about change. It was emphasised in Punch (2014) that a well stated research question indicates what data will be necessary to answer it hence, influence the design of the study. When a researcher is considering different methods, it is important to select the approach that has the most strength and fewest weaknesses in the context of the problem statement and objectives (Hernon, 2001).

Research design is described as fixed by Robson (2002) because all their components are determined in advance of the study being carried out. At the other end of the spectrum are research questions that are intended to provide general guidance to the research effort but that are more exploratory and open in their conception. Such questions call for research approaches that are more loosely structured and that will evolve as they proceed. The data collected are often less structured and open ended. The author further describes these research designs as flexible because they may be altered as the research progresses. An interactive approach to developing such designs was proposed, with the goals and research questions interacting with the selection of study methods during the course of the study; both the goals and questions and the methods are expected to change during the course of the study. The research question(s) you are asking have implications for several aspects of the study design. First, they have implications for the sample that will participate in the study. You will need to decide which people, organizations, settings, and so on are of interest (Maxwell, 2005).

This component of the study design is reflected in the perspective and setting components of the research question suggested by Booth (2006). Second, the questions have implications for the data to be collected. As you define each of the concepts incorporated in your question, you will need to decide what data can be used as an indicator for each. It was suggested by Mason (2002) that a researcher needs to ask, "Which of my research questions does each method or data source help me to address?" In this way, you can tightly link your data collection efforts (including both which data will be collected and how they will be collected) to answering your research questions. Finally, the research questions have implications for your data analysis methods. You will want to use those analysis methods that will help you focus your attention on answering your research questions.

Research Designs

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 or individual experiences from the perspectives of those involved (Powell & Connaway, 2004) is used as a means to develop theories to explain events or behavior. A qualitative research approach is exploratory, therefore, it is often used when a topic is new or little understood, or where "existing theories do not apply" (Creswell, 2003).

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). 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, 2003). Within this broad category are a variety of research designs, including case study, surveys, experimental, historical, cohort, citation, longitudinal, bibliometrics designs or techniques and so on. According to Hider (2008) the most predominant designs used in LIS research are: Case study, Survey and experimental designs. This chapter will discuss these three most used designs in LIS.

Case Study Research (CSR)

Like other social science research, library and information science (LIS) scholars have adopted case study methods for decades. In a research context, a case study is defined as a research study which focused on a single case or set of cases. Case studies are means of reporting an in-depth observations and explorations of an individual, population, process, technology, or service (Eldredge, 2001). No baseline information is collected and no comparison groups are used. The CSR is mostly seen as a research approach, rather than a specific research design, because a variety of designs and methods of data collection and analysis can be used to accomplish the goals of a particular case study.

Although the standardization of its definition and scope is still debatable, Benbasat,Goldstein, and Mead (1987) listed 11 key characteristics of case studies :

1. The phenomenon is examined in a natural setting.
2. Data are collected by multiple means.
3. One or a few entities (person, group, or organization) are examined.
4. The complexity of the unit is studied intensively.
5. Case studies are more suitable for the exploration, classification, and hypothesis development stages of the knowledge-building process; the investigator should have a receptive attitude toward exploration.
6. No experimental controls or manipulation are involved.

7. The investigator may not specify the set of independent and dependent variables in advance.

8. The results derived depend heavily on the integrative powers of the investigator.

9. Changes in site selection and data collection methods could take place as the investigator develops new hypotheses.

10. Case research is useful in the study of "why" and "how" questions because these deal with operational links to be traced over time, rather than with frequency or incidence.

11. The focus is on contemporary events.

Most often, case studies are qualitative and conducted in the field (Darke *et al*., 1998; Edgars, 2004; Fidel, 1984; McTavish & Loether, 1999). Yin (2003) pointed out that the evidence collected in case studies may be either qualitative or quantitative or both. The combination of both types of evidence could contribute to the validity of the method. Additionally, the flexibility of this method could be considered strength or a weakness.

When Should the CSR be used?

The research question is the most critical criterion in selecting your research method. Specifically, according to Wildemuth (2017), the following questions should be taken into consideration to judge the appropriateness of using a case study as research strategy:

1. Does the phenomenon of interest have to be studied in a natural setting?
2. Does the phenomenon of interest focus on contemporary events?
3. Does the research question aim to ask "how and "why" questions?
4. Does the phenomenon of interest include a variety of factors and relationship that can be directly observed?

Case studies are often used in exploratory studies to define phenomena worth studying further. For example, to explore the relationship between information search strategies and personal development theory, Kari (2006) conducted a case study of a single person by interviewing and observing information seeking on the Internet. When the research is highly exploratory, a case study can be used as a pilot study for trying out particular *data collection methods* in a specific context or to help the researcher become more *familiar with the phenomenon* in a specific context.

A case study may also be used to follow up on an exploratory study conducted with another method. For example, Boyd-Byrnes and Rosenthal (2005) conducted a study to examine roles of librarians in remote access and their impact on the quality and effectiveness of the research

process. Open-ended interviews were conducted at the preliminary stage to ascertain the important factors to investigate further. Then the case study protocol was used to follow up on those factors. Although a case study can be used to follow up on a preliminary study, its weakness is its lack of generalizability. Thus the research findings, rather than contributing to theory testing directly, usually provide evidence for hypothesis generation (Darke *et al*., 1998).

A case study approach can also be used in descriptive research to depict comprehensively the phenomenon of interest. For instance, to examine the organizational restructuring of an academic library from decentralization to centralization, Moran (2005) selected Oxford University's libraries as perhaps the largest and most complex case with which to examine this phenomenon. Because the Oxford libraries were in the process of restructuring, she was able to follow this process over a seven-year period. In this particular study, the case study method allowed the researcher to describe different aspects of the restructuring, including chronological, operational, and role-based foci. In summary, case studies are useful in many different types of research studies: exploratory and confirmatory, descriptive and evaluative. As Gray (2004) notes, "the case study method is ideal when a 'how' or 'why' question is being asked about a contemporary set of events over which the researcher has no control.

Designing a CSR

The first step in designing a case study as applicable to other research approaches is to:

1. Clearly define the research question. This is because many case studies are exploratory, the theoretical and empirical literature may provide only a vague foundation for the study (Eisenhardt, 1989).
2. Thorough literature review will be required to put the questions in a better perspective.
3. Identifying of unit of analysis "is the major entity that you are analyzing in your study" (Trochim, 2006). Most studies focus on individuals as the unit of analysis, but other possibilities include aggregate entities like groups or organizations, projects, or events such as decisions made or information-seeking episodes. A primary defining characteristic of a case study is that it focuses on a single instance of the unit of analysis.
4. Selecting the case or cases that will be the focus of your study. Some studies will focus on a single case, while others may compare two or more cases. Multiple-case studies (also called comparative case studies) are basically a combination of two or more single

case studies. This approach contributes to cross-case analysis and the extension of theory to additional individuals or settings. However, a single case study provides in-depth investigation of and rich detail about phenomena. Yin (2003) identified five possible reasons for selecting a particular case as:

i. it is a representative or typical case that captures the circumstances and conditions of an everyday or commonplace situation;
ii. it is a critical case that is essential for testing a well-formulated theory;
iii. it is an extreme or unique case that represents a rare phenomenon that needs to be documented and analyzed;
iv. it is a revelatory case that illuminates previously inaccessible knowledge; or
v. it is a longitudinal case that can be repeatedly studied at several different points in time.

5. Planning your data collection procedures. Since a case study is intended to generate rich data concerning a particular case, it is almost expected that multiple methods of data collection will be used. These methods might include analysis of existing documentation and archival records, interviews, direct observation, participant observation, and examination of physical artifacts (Yin, 2003). Also, quantitative methods, such as questionnaires, may be integrated into the research design. The results from the different data collection methods are combined through triangulation. Triangulation is a process of using multiple perceptions to clarify meaning, verifying the repeatability of an observation or interpretation (Stake, 2000).

Triangulation may be categorized into the following four types identified by Denzin (1978): (1) data triangulation (combining data from different sources); (2) investigator triangulation (combining data collected by multiple researchers); (3) methodological triangulation (combining data collected via different methods); and (4) theory triangulation (combining data collected from multiple theoretical perspectives). This fourth type, although possible, is quite rare in LIS and other social science research. The others have all been used in LIS studies and, in fact, could all be included within a single case study. For example, imagine a research team studying the application of Web 2.0 in a particular library.

The team will need to integrate the data collected by each researcher, requiring investigator triangulation. In terms of data triangulation, the team will gather data from several sources: cataloguing staff, executive staff, policy and procedures manuals, and Web server transaction logs. In terms of methodological triangulation, you may have used direct observation of the workplace, interviews (with staff), content analysis (with policy manuals), and transaction log analysis (with the Web server logs). In each case, the triangulation process will require the comparison of findings from each investigator/ source/method, cross-checking carefully to ensure that the study findings are valid conclusions drawn from the data.

Strengths and Weaknesses of Case Studies

The inability to generalize the outcome of the study is the main weakness of case studies most cited by its critics. There is no basis for generalizing the findings of a case study beyond the setting(s) in which it was conducted. Therefore, Stake (1995) turned this weakness to strength by insisting that "the real business of a case study is particularization, not generalization". Thus Stake pointed to the greatest strength of a case study: the richness with which a particular setting or phenomenon can be described using this approach. Also, Yin (2003) addresses the initial criticism in another way, by arguing that the results from case studies are generalizable to theoretical propositions. It was emphasized by Hammersley (1992) that theory can be tested through case study research if cases are selected in such a way as to open the theory up to maximal threat.

In this way, a single case can be used to test a theory against a particular set of empirical circumstances, even though it cannot be treated as a representative sample from a population.

The overall quality of case study research has sometimes been criticized. When evaluating the strength of a particular study, the study report will be the focus of attention. A reader should be able to evaluate how good the study is by reading the research report. However, case studies are more practical and it is the large amount of qualitative data that needs to be organized and analyzed. As discussed earlier, various data sources and data collection methods are being used. Therefore, a researcher needs to develop consistent and thoughtful procedures for organizing and analyzing such data.

Survey Research Design

Survey research is a popular method used to elicit responses from respondents. However, it does not mean they are simple to design and administer. Effective survey research design involves extensive planning. The research objectives should be carefully considered when planning participant recruitment, design and administration of the survey, and data analysis. Dillman (2007) opined that survey research is a useful method, enabling researchers to statistically estimate the distribution of characteristics in a population, based on a sample that is only a fraction of that population. Survey research designs are appropriate to investigate many different Library and Information Science (LIS) research scenarios, from information behaviors to service quality to satisfaction of staff and so on.

Conducting Survey Research

Dillman (2007) states that the design of effective survey research involves "many decisions which need to fit together and support one another in a way that encourages most people to respond and minimizes inaccurate or inadequate answers". Survey research design is dependent on careful planning to a series of critical components to ensure effective data collection and implementation. Here, the focus will be on designing the survey instrument; pretesting and pilot testing, with revision as necessary; survey administration; and data analysis.

Designing the Survey Instrument

A survey is a set of items, formulated as statements or a question which is used to generate a response to each stated item. Dillman(2007) and Czaja and Blair (2005) reported that designing the survey instrument is a critical task in planning survey research because it will influence the number of responses received and the validity of those responses. A good survey is brief and simple to complete, both in terms of organization and wording, so as not to demand too much effort on the part of respondents. Survey design is an iterative process, involving thoughtful drafting and organization of questions and response categories, then subsequent evaluation and revision as necessary until it's ready for distribution. Before the survey, literature in the area of interest should be examined. Studies that may have posed similar questions should be consulted and consideration should be giving to using or revising the surveys employed in those studies. If appropriate, the authors of previous studies could be contacted to get more information on their study procedures.

Peterson (2000) provides a seven-step framework for survey construction, and Dillman (2007) offers 19 principles to consider when composing questions. These are summarized below according to Wildemuth (2017):

- Ask only what can be answered, and ask only what is necessary to satisfy the objectives of the research investigation.
- Questions should be asked in complete sentences, diminishing the risk of misinterpretation.
- Use neutral language, avoiding words that could be misconstrued as subordinating, biased, or offensive.
- Consider the specificity of your questions. Questions should not be so specific that it impedes the ability to arrive at an appropriate response or so vague that they lead to confusion or frustration.
- Avoid double-barreled questions. For example, the question "Should the library invest in new electronic databases that allow patrons to access the databases remotely?" actually asks two questions: first, should the library buy new databases, and second, if so, should these databases be licensed so that they permit remote access by patrons? Make sure that each query posed is only asking one question of respondents.
- Participation in most survey research is voluntary, and as such, respondents should be in control of the extent of their participation. Do not burden respondents by requiring that each question be answered before respondents can continue with the survey (Dillman, 2007; Sue & Ritter, 2007).

Two questions are mainly asked in surveys: ***open-ended and closed-ended***.

Closed-ended questions are more commonly applied in surveys because they require less time and effort from the respondent and it is easier to analyze (Czaja & Blair, 2005).

They present respondents with a limited number of predetermined response categories. Attention will have to be paid in developing both the question and the list of possible responses.

Responses don't necessarily need to be provided than necessary, but ensure you provide all the responses that might be selected. When necessary (e.g., when one is not confident that all the possible responses have been identified), the list of responses may include an "other" category, accompanied by space for an explanation.

Open-ended questions do not necessarily present respondents with any response categories; rather, respondents compose and submit their own responses (Wildemuth 2017). An example open-ended question might be, "What if the library no longer provided internet connection for its users?" There is absolutely no way the researcher could reasonably construct response categories

to this question because it would be near impossible for the researcher to know all the possible responses.

In addition to developing the questions to be included in the survey, there is need to organize them appropriately. Peterson (2000) recommends arranging the survey into three sections: an introduction, a substantive questions section, and a classification questions section. The introduction section is the respondents' first interaction with the survey. It should engage respondents in the survey, encouraging continued participation and building rapport (Wildemuth, 2017). The first questions should also be relatively easy to answer (Dillman, 2007; Peterson, 2000). Questions essential to the research initiative are presented next, in the substantive questions section. This section is considered the heart of the survey. Within this section, related questions should be grouped together. If there are any questions that ask respondents to divulge sensitive information, those should be placed at the end of the section. Classification questions, the final section, gather basic information such as demographic information. These questions should be positioned at the end of the survey because, for the most part, the information collected is not essential to the research investigation and, second, answering usually requires little exertion on the part of respondents (Peterson, 2000). In addition to organizing the questions themselves, the physical appearance of the survey should be considered. For paper-based surveys, the layout should be attractive, using an appropriate amount of space between questions and sections, and selecting font sizes and styling that are easy for respondents to read (Wildemuth, 2017).

Pretesting and Pilot testing

Evaluation of the survey instrument prior to administering it to the study sample can ensure that the survey is both reliable and valid. This can be done using a couple of approaches. Here we'll classify these approaches into two groups: pretesting and pilot testing. Pretesting means the review of the survey instrument by experts or by members of the target audience. Pilot *testing*, means a realistic administration of the survey to a sample from the target audience that is not in the sample for the real administration (Wildemuth, 2017). Pretesting provides the opportunity to identify problems in the instrument, such as misleading questions or incomplete response categories or grammatical errors and misspellings. A pretest involves administering the survey to a small group of evaluators; the evaluators may be experts in the topic of the research or

members of the target audience. In its simplest form, the pretest will ask the evaluators for suggestions for improving the survey.

Using these methods, you can ensure that the survey items are being interpreted as it is intended. A pilot test, if appropriate, would follow the pretesting. In the pilot test, administration of the full-scale survey research design will be replicated, but to a small sample from your target audience. Depending on the research enterprise, pilot testing may not be possible or pragmatic because it demands more time, effort, and resources than a pretest. Particularly if your target audience is somewhat small, you may not want to pilot test because it decreases the number of people eligible for the survey research itself (Czaja & Blair, 2005).

Administering the Survey

Wildemuth (2017) advocates the following in administering a survey:

- E-mailing the survey to the respondents and asking them to respond by e-mail
- E-mailing a request to fill out the survey and asking respondents to go to a Web site to respond
- Arranging to administer the survey via a synchronous online chat session
- Posting the survey on a Web site and inviting visitors to the site to respond to the survey
- Phoning the potential respondents and asking them to respond on the phone
- Automatically phoning the respondents and asking them to respond by interactive voice response or touch-tone data entry
- Other variations on these approaches

There is “no one best method” for data collection; and indeed, there are advantages and disadvantages associated with each different technique (Czaja & Blair, 2005). When choosing the method for data collection, it is important to consider a number of factors, including available resources, time frame, staffing, and cost, among others. To consider the advantages and disadvantages of different approaches, self-administered surveys would be distinguished from other administered surveys (Peterson, 2000), and technology would be considered in delivering the survey and responses collected. The content of the survey, in terms of the types and number of questions included, will influence your decisions about the administration (Wildemuth, 2017). E-mail surveys may be ideal for very brief, simple surveys, while Web-based or printed surveys may be more appropriate for longer or more complex surveys (Dillman, 2007).

Analyzing the Responses

An important characteristic of survey research is that the data may be analyzed for both descriptive and comparative purposes (Czaja & Blair, 2005). Careful consideration of strategies for conducting the analysis should begin in the earliest stages of the design. Closed-ended questions afford more convenience and ease for analysis by presenting results that can be easily converted to numerals and calculated using statistical software applications. It is also important to carefully plan the response options for the closed-ended questions to optimize the ways in which the results could be analyzed. Analysis of responses to open-ended questions requires an additional step, analyzing and categorizing the responses, before additional quantitative analysis can be completed. In addition, the form of the data collection methods will affect the ease of the pre-analysis steps. Face-to-face and phone interviews as well as printed surveys require that response data be manually entered into whatever computer application will be used for analyzing data. Web-based surveys, on the other hand, compile the data at the point of data collection, removing a time-consuming step.

Experimental Studies

"By experiment we refer to that portion of research in which variables are manipulated and their effects upon other variables observed" (Campbell & Stanley, 1963). This basic definition provides a strong framework for understanding the primary characteristics of a true experiment.

First, some variables (i.e., phenomena that can vary in level or intensity, called *independent* variables) are manipulated. That means control must be exerted over their variation to understand the effects of their variation. The variable of primary interest is often called the *treatment* or *intervention* under study. The independent variables can be understood as the input to the experiment.

Second, we will observe those effects on other variables (called *dependent variables*). The dependent variables can be understood as the output from the experiment. For instance, we may want to know the effects of a new system design on the efficiency with which it allows its users to complete particular kinds of tasks. We will manipulate the system with which the study participants work to complete the task; for example, a group might be given a particular version of the system and another group a different version of the system. Then, the efficiency with

which the task is performed with each system will be observed. As seen from the definition of experiments, they are appropriate for those research questions with clearly stated hypotheses that can be tested in a well-controlled setting.

Experiments are characterized by control: the idea is that all the possibilities for variation are either controlled (i.e., held the same for all study participants) or they are varied systematically (e.g., the study participants experience either a high level or a low level of a variable of interest). A secondary characteristic of experiments is randomization as a means to exert control. Study participants may be randomly selected from a particular population. Study participants may be randomly assigned to one treatment or another. In each case, the randomization is performed to avoid any bias in the experiment's outcomes. It should be noted that randomization is a particular statistical process, not just a haphazard process. Experimental control and randomization allows to rule out all the possible causes of the observed effects other than the effects of the phenomenon of interest (Wiledrmuth, 2017). Thus, it can be argued that experiments are the only form of empirical research that provides leverage for discerning the causes of the phenomenon under study (Haas & Kraft, 1984).

Three Experimental Designs

Campbell and Stanley (1963) identify only three true experimental designs; two of those are most likely to be implemented in studies in Library and Information Science (LIS) research.

In addition, factorial designs are discussed here. You will find that one characteristic they all have in common is the random assignment of participants to groups. Carrying out this aspect of the design will be discussed after this introduction to the designs themselves.

Pretest-Posttest Control Group Design

This design, using Campbell and Stanley's (1963) notation, is depicted here:

Group 1: R *O* X_1 *O*

Group 2: R *O* X_2 *O*

From left to right, the columns represent the progression of time or stages of the experiment. Each row represents a group of study participants. For example, if we were comparing two information retrieval (IR) systems, one group would work with one of the systems and the other group would work with the other system.

The *R* at the beginning of each row indicates that study participants were randomly assigned to one or the other group.

Each *O* represents an observation in the study.

Each of the groups in this design is observed both before and after it has interacted with the system. For instance, one might be interested if interacting with an experimental IR system will improve people's attitudes toward searching. Respondents would be requested to fill out an attitude questionnaire before they use the system and after they use the system. Each *X* represents the intervention or treatment, that is, the experience that the study participants will have. For instance, they may interact with a particular system, or they may attend a particular workshop.

In some studies, one of the groups will be designated as a *control group* and will not receive any treatment at all. As an example, when implementing a new bibliographic instruction program in an academic library, we might have half of the first-year students attend it and not the other half (until after the study is over). However, these variations may be tweaked to suit appropriate situations.

Another common design variation is that the control group does experience an intervention, but it is normal practice, such as the current system in use or the current bibliographic instruction program. For our purposes here, we've designated two interventions; in other similar diagrams, there may be an intervention for only one of the groups. It should also be noted that this design can be extended to three or more groups. To recap, this design assigns subjects randomly to group 1 or group 2. A pretest is conducted with each group, and then each group experiences the experimental intervention appropriate for it (if any). Then a posttest is conducted with each group. Based on the results, intervention can be determined by comparing the posttest scores with the pretest scores (creating a change score for each group, i.e., a comparison across time).

The relative effect of the interventions can be compared using the change scores between the two groups. In addition, it can be verified that the random assignment to the two groups eliminated any bias by comparing the two groups' pretest scores. This design is powerful because it eliminates the possibility of bias in group assignment and allows investigation into the changes caused by experiencing the intervention.

Posttest Control Group Design

The posttest-only control group design doesn't have a pretest, which is the main difference between it and the previous design. The disadvantage is that changes can't be tracked in a

particular individual as he or she experiences the intervention. It is also completely reliant on randomization to ensure that the two groups are equivalent prior to the intervention:

Group 1: R X_1 *O*

Group 2: R X_2 *O*

However, there are also two important advantages (in addition to the obvious one: that a pretest doesn't have to be administered). First, if the pretest and posttest were to be administered within a short period, the pretest could affect participants' responses to the posttest. The participants might remember their responses on the pretest and either try to match them or try to change them. Second, depending on the focus of the study, the pretest can sometimes cause the study participants to experience the intervention differently than they would if they had not taken the pretest

Factorial Design

In the first two designs described previously, the research question is generally of the form, "Does this intervention make a difference in this outcome variable?" The independent variable in such a question can be thought of as a factor to be manipulated. If multiple factors are manipulated in the same experiment, a factorial design can be used. A factorial design simultaneously investigates the effects of all the independent variables (individually and in combination) on the dependent variables. The most basic factorial design is a 2 × 2 design, in which there are two factors(represented by the fact that there are two numbers in the name of the design), and each of them has two levels (represented by the fact that both numbers are 2). A research question for which a 2 × 2 factorial design would be appropriate is illustrated below:

		Specialized Reference Assistance	
		YES	NO
Attended Workshop	YES	GROUP 1	GROUP 2
	NO	GROUP 3	GROUP 4

Imagine that your school library has two new ways to improve students' success in locating appropriate source materials for their projects. The first is a small-group workshop in which the students were taught the most important sources in their disciplines while the second is

specialized reference assistance, with each student having an individual appointment with a reference librarian early in their research process. The question will be "which of these two methods is the most effective and do they have an additive effect?". The full sample of study participants would be randomly divided into four groups, based on the preceding diagram.

Group 1 would both attend the workshop and receive specialized reference assistance. Group 2 would attend the workshop but would not receive specialized reference assistance. Group 3 would receive specialized reference assistance but would not attend the workshop. Group 4, a true control group, would receive neither intervention.

Using this research design, then, the effects of specialized reference assistance by comparing groups 1 and 3 (combined) against groups 2 and 4 (combined) can be seen. The effects of the workshops by comparing groups 1 and 2 against groups 3 and 4 can also be observed. The researcher can also detect interactions between the two interventions by comparing the four group means. For example, those participants in group 1 may experience benefits that are more than the additive effects of the two interventions. Just as the previous designs can be generalized to compare three or more interventions, this design can also be generalized. More factors can be added. In our hypothetical example, you might also investigate the effects of the students' disciplines on their outcomes. If you grouped the disciplines into three groups (e.g., natural sciences, social sciences, and humanities), you would end up with a $3 \times 2 \times 2$ design. You can also have more than two levels of a factor, as was just illustrated by having three levels of the factor "discipline." Thus, this experimental design is very flexible and very robust.

The Validity of your Experiment

There are two types of validity. The first is *internal validity*, defined as "the validity of assertions regarding the effects of the independent variable(s) on the dependent variable(s)" (Pedhazur & Schmelkin, 1991). If internal validity can be achieved, then we can claim that the results observed are due to the variables manipulated, rather than other (i.e., extraneous) variables. As Campbell and Stanley (1963) declared, "internal validity is the basic minimum without which any experiment is uninterpretable: Did in fact the experimental treatments make a difference in this specific experimental instance?".Once you've established the internal validity of your findings, you can move on to the bigger challenge of establishing their external validity

(Bernard, 2000). *External validity* can be defined as the "generalizability of the findings *to* or *across* target populations, settings, times, and the like" (Pedhazur & Schmelkin, 1991).

The researcher will be trying to achieve external validity so that the result can be applied (and the conclusions drawn from them) to people beyond the study participants and settings beyond the laboratory.

"External validity asks the question of generalizability: To what populations, settings, treatment variables and measurement variables can this effect be generalized?" (Campbell & Stanley, 1963, p. 5). It is important to recognize and try to avoid some known threats to both internal validity and external validity (Campbell & Stanley, 1963; Haas & Kraft, 1984; Pedhazur & Schmelkin, 1991). Two threats to internal validity (attrition and contamination across groups) and two threats to external validity (interactions between pretesting and the intervention and interactions between selection/attrition and the intervention) are hereby di

Threats to Internal Validity

In Piper's (1998) paper on conducting social science lab experiments on the Web, she outlined how the same threats to internal validity described in Campbell and Stanley's (1963) work are manifested in the context of LIS research. Here, only two threats that are not eliminated through random assignment: attrition during the study and contamination across groups.

Attrition is the loss of some participants during the study. They may leave the study for a variety of reasons. If a few of the participants is lost after the study has begun (i.e., after they've been assigned to their individual groups), it's not a serious problem. However, the more attrition, the bigger problem it is. At some point, the random assignment which was begun will no longer be protected from bias because those who drop out of one group may be different from those who drop out of the other group. The recruitment processes, study procedures, and the incentives needs to be well planned for participation to minimize attrition among participants. The second threat to internal validity that needs to be watched out for, even with an experimental design, is contamination across groups. Such contamination means that members of the two groups have communicated with each other about the intervention and so may be influencing each other's reactions to it.

Plan your study procedures to avoid contamination across groups; it is appropriate to ask your participants not to describe the intervention to anyone else during the period when data are being collected for the study.

Threat to External Validity

It is almost impossible to have experimental results for which you can confidently claim external validity (i.e., results that can confidently be generalized to the population of interest and a range of relevant settings) (Wildemuth, 2017). First, you would need to have a sample of study participants that was drawn randomly from the population to which you'd like to generalize; this is rarely feasible. Second, the control exerted through an experimental design cannot ever truly reflect the messiness of the everyday situations to which we'd like to generalize our results. This problem is an inherent drawback of experimental methods and is sometimes referred to as the issue of *ecological validity*, or, alternatively, as the *reactive effects* of an experiment. Nevertheless, there are a few other threats to external validity that you should try to avoid through your sampling methods or experimental design (Campbell & Stanley, 1963; Pedhazur & Schmelkin, 1991).

One possible problem is an interaction between pretesting and the intervention under study. Pretesting can change the perspective of the study participants, potentially introducing unwanted and unknown factors into the experiment. Campbell and Stanley (1963) recommend study designs without pretesting as a means of avoiding this interaction effect, thus increasing external validity. A second possible problem is an interaction between the selection of study participants and the intervention. Comparable problems occur if the study sample suffers from attrition because the sample is no longer representative of the population of interest. Pedhazur and Schmelkin (1991) describe this phenomenon as "treatments-attributes interaction," appropriately placing the emphasis on the attributes of the study participants. For example, if you are studying how people interact with a college's online library catalog and want to generalize your results to all library users, then your sample needs to represent the full range of user attributes. The sample needs to include faculty, staff, and graduate students as well as undergraduate students to represent the full range of ages and levels of experience in using the catalog. If the attributes of the population are not well represented in the study sample, generalizability of the results to the population is limited.

Other Issues to Consider when Designing an Experiment

In addition to selecting a particular experimental design for the study and making every effort to avoid threats to internal and external validity, there more issues that are needed to be considered when designing an experiment: whether to conduct the experiment in the lab or in the field, whether to use a within-subjects or between-subjects design, that may arise in your interactions with the study participants.

Experimental Settings: Lab or Field

Conducting an experiment in the lab gives the most control over extraneous variables. For example, it is known that every participant use the same computer with the same network connections under the same conditions. Although this level of control is core strength of experimental designs, it may limit the external validity of the study's findings, as noted previously. Conducting an experiment in the field may increase its external validity. For example, participants are using the computer and network connections that they actually have available to them and the conditions are more realistic. However, it is often the case that a field experiment provides so little control that you can no longer consider it an experiment. The goals of the study need to be carefully considered to decide whether the lab or the field is a more appropriate setting for the study.

Within-Subjects versus Between-Subjects

One of the basic questions that is faced in setting up an experimental design is to determine whether you are using independent groups (i.e., a participant is in only one group and experiences only one intervention) or overlapping groups (i.e., each participant experiences multiple interventions).

The first of these cases is called a *between-subjects design* because the comparisons made during data analysis are comparisons between subjects. The second of these cases is called a *within subjects design* because the comparisons made during data analysis are comparisons within subjects (i.e., between each individual's outcomes with one intervention and the same individual's outcomes with another intervention). Some situations definitely call for a between-subjects design. For instance, if the interaction with the first intervention would have a very strong impact on the interaction with the second intervention, this threat to the internal validity

can be avoided by using a between-subjects design. This type of situation often arises when you are investigating the effects of different instructional approaches or comparing people's interactions with two different system interfaces.

If the study procedures are quite demanding or take a long time to complete, it may also be appropriate to plan to use a between-subjects design to minimize the burden on each participant. For example, if you want your participants to complete six to eight searches with a novel search engine, filling out a brief questionnaire after each search, it may be asking too much of them to then repeat the entire process with a second search engine. The biggest disadvantage of using a between-subjects design is that it requires that more subjects should be recruited. Thus, it is more costly, and a within-subjects design might therefore be preferred.

A within-subjects design is more efficient as opined by Wildemuth (2017) in terms of the use of the subjects because each person will contribute two or more data points to the analysis. It also allows asking participants for a direct comparison of the interventions (e.g., system) under investigation. In addition, it minimizes the variation in individual characteristics, making the statistical analysis more powerful.

Conclusion: It is crucial that a researcher understands the research question thoroughly and state it clearly, as this will help in choosing appropriate design for the research. A case study design is noted for examining contemporary events in a natural setting and answering how and why questions while a survey research entails choosing a sample, carefully designing survey instruments to elicit information from the later and analyse with the most suitable statistical tool. However, the principles of experimentation are relatively simple, it randomly assigns the subjects to two or more groups and measures the outcomes resulting from the intervention experienced by each group.

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