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**EXPERIMENTAL AND QUASI-EXPERIMENTAL RESEARCH IN INFORMATION SYSTEMS**

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**ABSTRACT**

There are numerous research methods and methodologies, which have been used in different fields of study. Crucially, not all of these approaches are appropriate for every project since they feature individual characteristics, strengths and weaknesses, which may make them appropriate for one project of study but unsuitable for another. Some fields of study, such as those examining social environments or human activity systems, are highly complex and it is necessary to investigate them by undertaking research in real time and within their own natural settings. Experimental research is appropriate for such studies as it enables researchers to study the real world in real time. Experimental research is cited as one of the few research strategies, which enables researchers to study cause and effect directly. It has been used in fields of study such as science, social science, information systems, software engineering and psychology. Different types of experimental research exist, such as controlled, laboratory and true experiments as well as also quasi-experiments. Despite it possessing such adaptability, experimental research has been criticised because of its lack of generalisability. This paper first defines experimental research and then proposes quasi-experiment research as one of its most used instantiations. In order to establish the importance and applicability of these research approaches, this paper will explore both weaknesses and strengths of these methodologies.

**KEYWORDS**

Experimental research, Quasi-Experiment, Information System.

**1. INTRODUCTION**

In all areas of research, various research methods and methodologies have been used to investigate different phenomena; every field of study (*environment*) has its own unique features and attributes which need specific methods for investigation. Understanding these features helps researchers to utilise the most appropriate methods and methodologies for investigation. *Method* mostly refers to a set of approaches, which is used in data gathering and analysis; this data acts as the foundation for deduction, understanding, justification or prediction (Cohen et al., 2010), that is, all those methods and techniques used in conducting the research (Korthari, 2006:7). Usually, the aim of *methodology* is to use sets of methods according to specific research paradigms and approaches in order to help the researcher to understand the phenomenon under study (Kaplan, 1973). In short, a research methodology is a “way of systematically solve [... a] research problem” (Korthari, 2006:8).

Some environments are particularly complex, and so to understand phenomena rooted in these environments it is often necessary to study it in real time. *Quasi-experiments* are designed to help the researcher to understand the intricate nature of the world by enabling them to study the environments in real time and in natural settings (Bryman, 2008). Nevertheless, although quasi-experiments are appropriate for investigating phenomena in real time, they also exhibit some disadvantages and weaknesses as described below.

This paper aims to define quasi-experiment approach, highlight its strengths and weaknesses and additionally provide examples of its usage in Information System (IS) research. According to Galliers (1992), IS is defined as part of a real world which includes objects (such as computers and other HW), people, rules, instruction for performing duties, and commands (like programs). Since, all IS require human beings to create, work with, and operate their HW components, it is in understanding this human interaction that lies the core of IS research. Quasi-experiments are therefore, crucial in enabling this understanding of human

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interaction. This type of method is similar to the 'true experiment' in many aspects so this paper also considers the true experiment definition, characteristics.

**2. EXPERIMENTAL RESEARCH**

Researchers generally seek to identify the most appropriate methods for establishing the cause and effect of a phenomenon on/from its surrounding environment. Researchers, using deductive approaches and experimental research, aim to find a hypothesis that can predict and explain the effect of specific variables on other variables. Experimentation enables the researcher to change the condition or value of one or more variables - usually known as independent, *imental*, or *treatment* variable - in order to observe or measure the impact on another variable, which is in turn called a ‘dependent, criterion or outcome variable’ (Smith, 1981; Cohen et al., 2010). Smith (1981:191) emphasises that the experiment is one of the few methods that directly concerns itself with the question of causality.

The experiment is usually known as ‘the research strategy’ in natural sciences such as physics, biology and chemistry. However, it has played a noticeable role in social science research as well, mainly in psychology (Saunders et al., 2003) and in IS research (Kaplan and Duchon, 1988). Galliers and Land (1987) add that experimental IS research is mostly suitable in improving knowledge on use and exploitation of specific artefacts, in particular conditions or by particular groups. However, there are very different types of experimental research designs. Cohen et al. (2010) propose a very useful characterisations as follows:

The *controlled experiments* which are conducted in laboratory conditions can be categorised in two or more groups. The laboratory experiment is also called the ‘true experiment’. It is not always possible to conduct experimental research in laboratory conditions - in some cases this is because of ethical issues or the specific field of study.

The *quasi-experiment* or field, research is conducted in a natural setting rather than laboratory conditions, but in this design, variables are isolated, controlled and manipulated.

The final category is the *natural experiment* where research is conducted in natural conditions, and the experiment itself, that is, variables are not controlled or isolate.

Bryman and Bell (2007) and Bryman (2008) believe that experiments are rarely used in sociology, but have been use occasionally since they can function as a measurement tool to assess the application of non- experimental research. An experiment has very high levels of internal validity, which can be achieved when the research method disapproves substitute hypotheses that are established as part of the experiment research design (Smith, 1981). Bryman (2008) claims that the findings of experiments are reliable and strong and, as such, an experiment is highly dependable in terms of internal validity. Internal validity is defined as a “concern with the question of whether a finding that incorporates a casual relationship between two or more variables is sound” Bryman (2008: 694).

In conducting experimental research, two different types of groups are normally used: the experimental or treatment group and the control group. Researchers experiment by changing conditions of experimental groups whilst control groups do not receive any experimental treatment. According to Cochran and Cox (1957) the term ‘treatment’ is assigned to dissimilar processes which affect variables - this impact is the subject of the study and is to be measured and compared with control groups. In general, an experiment is concerned with changing one independent variable and investigates the effect on dependent variables (Bryman, 2008; Cohen et al., 2010). During the experiment, the researcher can manipulate the independent variable in order to verify its influence on dependent variables. When the researcher uses more than one experimental group, each of these groups are treated with different levels of the independent variable to illustrate the differences between the groups. Manipulation involves the changing of the conditions of the experiment in order to establish if it causes one or more changes to the other variables (Bryman, 2008). However, it should be considered that most independent variables, especially in the social sciences, cannot actually be easily manipulated; for instance, when studying the effect of gender on using new technology, the variable ‘gender’ cannot be manipulated. In simpler terms, experimental research could be seen as a test or set of tests that make purposeful changes to the input variable of a process or system in order to observe and understand the effect of those changes on output variables (Montgomery, 2008).

Because of these characteristics, Fraenkel and Wallen, (1993) believe two main aspects of experimental research can be considered unique: firstly, experimental research is one the few research strategies which

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attempts to impact upon specific variables directly, and secondly it is probably the only strategy that tested hypotheses in relation to causality. Since, it is the specific characteristics of experimental research that have made one of the oldest methodologies in use and probably the most prevalent one in science, this paper will discuss them in detail before introducing its application.

**2.1 Comparison of Groups**

As mentioned before, an experiment usually contains two groups of subjects - the control and experimental groups. According to Fraenkel and Wallen (1993), it is possible to conduct experimental research only when providing all treatment to one subject. All members of the experimental group then, are treated the same as each other, while the control group receives no treatment. The control groups play a critical role in this research strategy since they are used as a basis for comparison - researchers can identify whether the treatment has had any influence on variables and can also understand if one treatment has had more impact on variables than the others.

**2.2 Manipulation of the Independent Variable**

In all experimental research, researchers manipulate the independent variable. In other words, researchers determine what treatment the independent variable will get and which group will receive a particular treatment. As highlighted before, the fact that not all variables can be manipulated should be considered when establishing the research design for the study.

According to Fraenkel and Wallen (1993), in experimental research the independent variables can be configured in differing ways:

1) One kind of variable against the other - for instance, a study comparing a feature of a new IS system versus a similar feature on an existing system in an organisation;

2) The presence of a certain item against its absence - for instance, the impact on an organisational socio- technical environment of the absence of a particular feature in a new system vs the availability of the same feature in an existing one.

3) Different levels of the same kind of variable - for instance, studying the effect of different amount of training on user' attitudes towards a new system.

In (1) and (2), the variable is completely categorised, however in (3) the variable is quantitative - the amount of training.

**2.3 Randomization**

In experimental research, researchers are expected to allocate subjects to groups randomly. This random assignment is found to be an important aspect of most experimental research by Fraenkel and Wallen (1993). In some research areas, full random assignment of subjects is not possible (e.g. when asking for volunteers to participate in the experiment), in this case of self selected samples researchers are still expected to use randomization as much as possible. In this case it is still possible to undertake *random assignment*, which means that all participants have equal chance to be assigned to either an experiment or control groups. However, if volunteers are asked for, the *random selection* is not possible anymore as not all members of the researched population have an equal chance to be selected as part of the research sample.

Random assignment is a process of allocation rather than distribution and usually takes place before the actual experiment begins and when the experimental groups are formed. Cohen et al. (2010: 276) define it as:

*“Randomization, then, ensures the greater likelihood of equivalence, that is, the apportioning out between the experimental and control groups of any other factors or*

*characteristics of the subjects which might conceivably effect the experimental*

*variables in which the researcher in interested.”*

Additionally, random assignment reduces the risk of additional unwanted confounding variables related to group composition. Nevertheless, without a reasonably large group, random assignment cannot guarantee true and full randomisation. Unfortunately, there is no specific definition for ‘large group’ so the term ‘large’ is somewhat vague and subject to interpretation by the research team.

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**2.4 Internal Validity**

As mentioned above, experimental research offers high levels of internal validity since it provides greater control over different elements of the research such as choosing the sample, determining the treatment as well as controlling external factors and confounding variables (factors that are not part of study but can have an impact on dependent variables). On the other hand, since the higher levels of internal validity in experimental research is predicated in the control of all elements of the experiment, failure in controlling these elements and other external factor on the dependent variables may cause critical impact in the findings and results of the research. Therefore, researchers try to minimize the risk of the effect of any unwanted factors by applying different strategies like randomization, the largest possible number of subjects and statistical testing.

In experimental research defining the experimental groups is possibly the most critical element of guaranteeing internal validity. Researchers should ensure that all groups are randomly assigned, similar and of the same nature in order to avoid unwanted effects. However, in addition to randomization, researchers can simply eliminate the unwanted effect of known confounding variables by removing any know causes of impact of that variable in the study. Conversely, researchers may choose to explicitly add or built in these confounding variables into the study. Finally, subjects can be used as control mechanisms as wells, meaning that researchers can triangulate by examining the same experiment group under different conditions and then compare the results with each other. Each of these control strategies can help researchers to design better experiments*. Good design* refers to research design, which guarantees the control of as many of the unwanted effects of external factors, which can threaten the internal validity of an experiment. Weak design refers to designs with poor control over threats to internal validity.

**3. DESIGNING EXPERIMENTAL RESEARCH**

The basic steps for designing an experiment, as outlined by Saunders et al., (2003), are:

1. Defining the problem and the research questions;

2. Identifying the population of interest;

3. Define the need for sampling and allocation the samples to different experimental situation depends on research aims;

4. And finally define the experimental design in three steps:

Introduction of planned change on some variables; Measure on small number of variables; and

Control of other variables.

The first three steps mostly resemble other research strategies (Bryman, 2008), but the last step is very specific to experimental research. In order to better explain experiment design, this paper uses the symbols and conventions from Campbell and Stanley (1963) which are also adopted by Cohen et al. (2010):

χ - symbolizes the relation of a group to an experimental variable or change and the result will be measured and studied.

О - symbolizes the observation and measurement process.

χ**s** and Оs are allocated to a participant or variable in a given row. Left to right order shows time-related sequence.

χ**s** and О**s** vertical to one another are concurrent.

**R** - symbolizes random allocation to a separate treatment group.

Parallel rows, which are not separated by dashes, symbolize comparison groups that are linked by randomization.

Parallel rows that are separated by dashed lines, showing experimental and control group are not equated by randomization.

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**3.1 True Experimental Design**

True experiment as defined above may be implemented using very different designs. The most commonly used designs were discussed by Campbell and Stanley (1963) and (Cohen et al., 2010) as follows:

1. Pre-test-post-test control and experimental group design - in this design, both groups are observed or measured twice. The first measurement is conducted as the pre-test, then the treatment occurs and finally the post-test is undertaken. In addition, to form the groups, random allocation is used (Fraenkel and Wallen,

1993). As mentioned above, randomization helps the researcher to guarantee the possibility of equivalence being increased. However, this process poses some risks. The performing of the pre-test increases the opportunity of an “interaction of testing” and can represent a threat for the treatment, since it can actually act a preparation for the members of experimental groups and as a result have an impact on their performance (Fraenkel and Wallen, 1993).

Experimental RO₁ χ О₂

Control RO₃ O₄

2. Two control groups and one experimental group pre-test-post-test design - this design was proposed

and improved by Solomon (1949) and aims to recognise the interaction effect which might happen if subjects infer or learn from the pre-test. This design is similar to the previous one, but uses two control groups instead of one. In this design, the second control group receives the treatment and does not perform the pre-test. As a result, the change in the latter group only takes place on treatment and not during pre-test.

|  |  |  |
| --- | --- | --- |
| Experimental | RO₁ χ | O₂ |
| Control₁ | RO₃ χ | O₄ |
| Control₂ | χ | O₅ |

3. Post-test control and experimental group design -in this design, control over specific threats are high because variables are randomly allocated to both experimental and control groups. Like all experimental research, the experimental group receives treatment and both groups only receive post-test. Since the groups are tested once, the possibility of effect of test on members is low (Fraenkel and Wallen, 1993; Cohen et al.

2010).

4. Post-test two experimental groups design - The variables are randomly assigned to each of experimental design groups. Each group receives a set of treatment, which is different to that of the other group. Both groups are performed only post-test. Robson (1993) states that this design is probably the simplest experimental design. The variances between two post-tests show the different impact of two treatments.

Experimental₁ R₁χ₁ O₁

Experimental₂ R₂χ₂ O₂

5. Pre-test-post-test two treatment design - This design is similar to the previous one except both groups

receive pre-test and post-test individually and the changes are measured.

Experimental₁ RO₁ χ₁ O₂

Experimental₂ RO₃ χ₂ O₄

6. Matched pairs design - All members of groups are assigned randomly to both experimental and control

groups. “Matching pairs of subjects” is the outcome of pre-tests where participants receive very similar scores on related variables which are relevant to the experiment in question (Robson, 1993). Subjects can be matched on variables such as age, gender and their scores from intelligence or personality tests. The foundation of this design is that each member of the experimental group is matched to a member of the control group (Cohen et al. 2010).

7. Factorial design - according to Fraenkel and Wallen (1993), factorial design enables researchers to investigate the interaction of an independent variable with the dependent variable. This design may involve

‘moderator variables’, which are variables that alters the strength of the causal relationship between the independent and the dependent variables.

8. Parametric design - Like other designs members of each group are allocated randomly to different groups and then receive fixed levels of the independent variable (Cohen et al. 2010). Robson (1993) explains this as the treatment of a set of different levels of an independent variable in order to observe the wider effect of treatments and their effects.

9. Repeated measures design - In this design, the same members of experimental groups receive more

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than two experimental treatments. This design is suitable when the order of treatments is not important. Also, it can help the researcher to distinguish vague treatment effects from individual differences (Robson,

1993; Cohen et al. 2010).

**3.2 Quasi-experimental**

These are the most popular designs as presented in the experimental research literature. There may other designs of true experiments, but the important aspect is that they contain the following main attributes (Fraenkel and Wallen, 1993):

One or more control group and experimental group;

Random assignment of subjects in both control and experimental groups; Pre-test of groups to check the equality;

Post-test of groups to identify the impacts on dependent variables; One or more treatment on the experimental group/s;

Isolation, control, and manipulation over independent variables;

‘Non-contamination’ between experimental and control group.

By definition if an experimental lacks any of these attributes, then it becomes a quasi-experiment (Cohen et al., 2010). This is not necessarily negative, in some fields of study quasi-experiment it is seen as an improvement to true experimental design, since not all phenomena can be studied in laboratory conditions (Bryman, 2008; Cohen et al., 2010).

Quasi-experiment in IS can also be conducted in a natural setting by involving manipulation of the social setting and by introducing changes in socio-technical environment. Additionally, in quasi-experiments, changes to independent variables may also happen naturally rather than through manipulation (Grant and Wall, 2008). In this case, the experiment has a looser control over the treatment. In some of these cases of natural quasi-experiments, it may be impossible to allocate subjects randomly to both experimental and control groups so (as mentioned above). This lack of random allocation means that the groups may not be equivalent and consequently weakening internal validity of the research. However, this type of experiment has significant advantages, since the research settings have higher levels of authenticity and are not contrived, designed or artificial (Bryman, 2008). Bryman (2008) finds that quasi-experiment has been used more in evaluation research. Nonetheless, because quasi-experiments provide less control over the conditions or unwanted external factors of the experiment, deducing causality is more contestable. In discussing potential unwanted external factors or extraneous confounding variables, Cohen et al., (2010) highlight the following ones:

*Participant factors* - some critical characteristics might be different between control and experiment groups;

*Intervention factor -* sometimes the intervention is not same for all participants as it can differ in sequence, level of intervention and duration;

*Situational factors -* the experimental setting might be different.

If any of these factors are not properly anticipated, monitored and controlled, then the result may not be reliable since the effects of the independent variables being tested may be compromised by these external confounding variables.

**3.2.1 Quasi-experiment design**

According to Cohen et al., (2010) quasi experimental designs include:

1. Pre-experimental designs:

o the one-group pre-test-post-test - in this design, the researcher measures a group on a dependent variable, followed by an experimental manipulation of the independent variable and finally then measures the effect again on the same dependent value. The difference between two tests can show the effect of manipulation.

Experimental O₁ χ О₂

o the one group post-tests only - the experimental group receives treatments and then the post-test is conducted. This may be a problematic design in quasi-experiments due problems of internal validity related to the lack of control and randomization of the group.

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o the post-tests only ‘Non-equivalent’ design – this is a design that is very similar to the previous design, except it is aimed at natural experiments where randomization, pre-test and matching with control group is not possible.

2. Pre-test-post-test ‘Non-equivalent’ control group:

This design is known one of the most common designs by Cohen et al. (2010). This designed is improved by adding a control group. The equivalent of groups can be achieved by matching and it is suggested that if matching is not possible researcher can choose sample from same or very similar populations. Robson (1993) states that this design is created to strengthen the pervious quasi-experimental design by combining the two designs ‘the one group post-tests only’ and ‘the post-tests only ‘Non-equivalent’ design’.

Experimental O₁ χ₁ O₂

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Control O₃ O₄

3. The interrupted time series design - This design includes repeated measurements or observation in a

specific time frame, both before and after treatments. This design is not particularly strong at controlling for threats of contamination, but fairs better than some of the proposed above as the research team will have a history of the treatment administration and can apply statistical regression to improve internal validity.

These designs have been used often in the field of IS, as for instance in the research project reported by Kampenes et al. (2009), which shows the use of quasi-experiment in software engineering, or the work of Adelman (1991), who reviewed the use of empirical methods for the evaluation decision support systems.

Fraenkel and Wallen (1993) and Adelman (1991) state that since the use of random allocation is not included in quasi-experiment design, researchers who use this research strategy tend to use other techniques in order to control and reduce the risk of threat to internal validity. Some of these techniques include the matching-only design, the matching-only post-test-only control group design, and the matching-only Pre-test- post-test control group design.

Kampenes et al. (2009) cite Cook and Campbell (1979) in proposing the critical success factors for the implementation of quasi-experiment research:

1. Carefully crafted design that guarantees appropriate amount of information to explain the phenomenon being studied;

2. Open-minded use triangulation and multiple analyses in order to achieve better explanatory results; and

3. Use of an explicit evaluation of the findings validity and the plausibility of substitute explanations.

**4. QUASI-EXPERIMENT STRENGHTS AND WEAKNESSES**

Like all research strategies, quasi-experiment has both negative and positive sides, some of which are inherited from true experimental research as mentioned above. The specific nature of quasi-experiments emerges, as discussed above, from the lack of complete researcher control over the experiment, which provide the methodology with both weaknesses and strengths.

**4.1 Weaknesses**

In addition to the remarks made above in these paper on the weak internal validity, Smith (1981) states that the second most significant weakness of experimental design is the problem with external validity, which is defined as the “concern with the question of whether the results of study can be generalized beyond the specific research context in which it was conducted” (Bryman, 2008: 694). The 'dilemma' is how generalisable the findings are. However, this author believes that generalisation is actually a weakness of all research methods to some extent. Generalisation as a weakness of experimental research is often mentioned in the literature such as Adelman (1991), Dennis and Valacich (2001) and Grant and Wall (2008). Adelman (1991) states the problem exists in experiments, in general, because of the small sample sizes used and in quasi-experiment, in particular, due to non- random allocation.

Smith (1981) adds that experimental design is usually difficult to design and can be highly time- consuming. This may be a concern for short research projects or projects that are poor in resources.

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An additional set of considerations that may represent a weakness and a problem in experimental design is related with choosing an adequate subject pool. Finding participants is a critical element that needs to be done with care, because generalisability is the key contribution for the validity of the research findings (Dennis, 2001). In fact, is in the availability of the participants and the logistics of their recruitment and participation that lie some of the more crucial difficulties with quasi-experiments. Students are often used, as shown by very large number of publications that report social sciences, IS and e-learning experimental research projects that rely on them as informants. In fact, students are almost always available and willing to participate in experiments, but in contrast, recruiting high-level executives, managers, IT professional traders, or IS professional users is often difficult or impossible. This leads sometimes to the use of “convenience samples" (Dennis and Valacich, 2001). This is an attitude to be avoided, participants must be drawn from a sampling frame that fits the theory and that exhibits the desired characteristics for the experiment (Dennis and Valacich, 2001).

Furthermore, Adelman (1991) cites sample size limitations as one of the important shortages of quasi- experimental research. Since this research strategy involves a larger number of dependent variables and different levels of experience, it follows that a large population is required in order to make meaningful inferences. As stated above, this is not always possible in all circumstances. Consequently, Adelman (1991) proposes that all three quasi-experiment designs threaten statistical inference validity.

**4.2 Strengths**

When considering all the weaknesses of experimental research, it may reasonably be asked why this research strategy is so popular, spanning as it does so many different fields of study such as psychology, computer software engineering, information system, etc. Smith (1981) answers this question by highlighting the incapability of other research strategies to identify cause and effect. Experimental research is in fact one of the few research strategies which enables the study of causality in the real world and in real time.

In addition to these unique features of experimental research, Grant and Wall (2008) identify five benefits:

a) When random allocation and control manipulation is impossible or has ethical issues, quasi-experiment can strengthen casual conclusion deductions;

b) Define improved theories and temporal progression;

c) Reduce ethical issues of different elements such as abuse, deception and paternalism;

d) Encourage constructive engagement with participants;

e) Use context to explain the conflicts in findings.

**5. CONCLUSION**

This paper has defined experiment, experimental research and quasi-experimental designs. It also described and discussed characteristics of the different experimental research designs and their attributes. The paper argued that, in relation to IS, quasi-experiments may be viewed as an improvement to true experimental research, as the socio-technical phenomena studied by IS cannot usually be studied in laboratory conditions. However, it was argued that internal and external validity maybe considerably weakened due to the lack of random selection of participants and difficulties in random allocation to both control and experimental groups. The paper also argued that the ability to research in the ‘real world’ in ‘real time’ and, more importantly the ability to study cause and effect directly have also been put forward as the greatest strengths of quasi-experiment, which equip the researcher with a unique features to understand the socio-technical environment of IS.

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