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# CS7CS6: Research and Innovation Methods

2021-2022

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# CS7CS6 – Common Phases of Research Process

| Phase | Goal | Possible Outputs include |
|---|---|---|
| Idea-Generating Phase | The goal of this phase is to have chosen a research area of interest based on personal experience, published work of others, ideas mentioned by others in future work sections of papers and dissertations. | Research Plan<br>Research Proposal<br>Ethics approval application<br>Interview questions<br>Questionnaires<br>Focus Groups Questions<br>Experiment design<br>Presentation<br>Paper<br>Dissertation |
| Problem Definition Phase/ Background | The goal of this phase is to have one or more questions(that is answerable) based on others work and your own ideas. You may also be investigating background information on tools/technologies. | |
| Procedures-Design Phase | The goal of this phase is to have a plan of what methods you will use to answer your research question in an ethical fashion, with your available resources and skills and based on how others answer questions of your type and within a research framework. | |
| Observation Phase/ Action phase | The goal here is to conduct some primary research which involves doing something practical- prototyping, managing/processing data, testing, evaluating, designing etc. | |
| Data Analysis Phase | The goal here is to analyse the data you have collected in a way that allows you to answer your question. | |
| Interpretation Phase | The goal of this phase is to place the findings from the literature and your primary research together in a way that answers the research question you asked. | |
| Communication Phase/ Ongoing | The goal here is to present in a formal or informal way, 1)what you have done, 2)your motivation for doing it, 3)how you did it, 4)how it fits in with others work, 5)your findings, 6) limitations and 7)possible future work. | |

Compiled and modified from - Research Methods, a Process of Inquiry, A. Graziano, M. Raulin, 2014.

# CS7CS6–Asking/Answering Questions?

## Why are Yawns Contagious?

https://www.thoughtco.com/why-are-yawns-contagious-4149534

- **Systematic observation**
- **Rational Processes**
- **Seeking Knowledge**
- **A process of creating specific questions**
- **Refined process of questioning**
- **Systematically finding answers**
- **A process of Inquiry**
- **A particular way of thinking**

"Science, one of several ways of learning about the world, uses systematic observation and rational processes to create new knowledge. Scientists seek knowledge through a refined process of questioning. We want you to know that in science, knowing how to ask questions is as crucial as knowing how to answer them…… Scientific research is a process of creating specific questions and then systematically finding answers. Science is a process of inquiry- a particular way of thinking." Research Methods, a Process of Inquiry, A. Graziano, M. Raulin, 2014.

# CS7CS6 – Answering questions- How

**Building Prototypes**

**Data Collection**

**Analysing Data Sets**

**Focus Groups**

**Subject Area Analysis**

**Interviews**

**Comparisons**

**Literature Review on Subject Area**

**Evaluation**

**Your Research Question dictates the methods you should use!**

**Check the literature to see how other researchers have answered similar questions**

# CS7CS6 – Interviews

Use when trying to collect in depth knowledge/views on a topic or context e.g. underlying reasons and motivations for people's attitudes, preferences or behaviours. Usually used when you want to collect data from people who are very knowledgeable about your topic of interest.

The interview can be structured, semi-structured or unstructured. The questions need to be carefully chosen and carefully asked to extract the data of interest. Can use face to face meetings or telephone calls.

| Advantages | Disadvantages |
| --- | --- |
| Immediate responses | Time consuming to collect and analyse data |
| Target people who are knowledgeable about the topic | Inconsistency  if more than one interviewer used |
| In depth questions- Can result in rich data and insights and opinions about that data | For face to face interviews there may be geographical constraints |
| You can show artefacts e.g. devices, user interfaces, diagrams | Need appropriate location for interview |
| Can use recording equipment to create raw data. | Interviewer needs to have a good rapport to extract the required data. |
| Can answer concerns or provide clarity for potential participants. | Dependency on a small amount of people. Need to select the appropriate participants. |

# CS7CS6 – Questionnaires

Use when you have set information to collect from a large number of people and you are not interested in collecting in depth knowledge about a topic or context. Piloting the questionnaire is a good idea as part of the refinement of the questions.

Questionnaires are a popular means of collecting data but can be time consuming to design. The questionnaire can be designed by the researcher and must be informed by the literature or it can a standardised questionnaire which is found in the literature. They can include open ended and closed ended questions. Open ended questions will have a text based answer and closed ended questions will provide a set of pre-defined answers to choose from

| Advantages | Disadvantages |
|---|---|
| Are very inexpensive way of collecting data | Wont usually provide data about context |
| Lots of tools for creating questionnaires and analysing data | Requires domain knowledge to develop a questionnaire |
| Anonymity | No visibility of who is completing the questionnaire |
| Respondents can consider their responses without influence and can participate in their own time | Usually low response rates, waiting for replies, need to send reminders. |
| Need access/permission to use email addresses for email contact | Not everyone can complete questionnaires |
| Usually, no geographical constraints | Self selecting group |



https://www.bcps.org/offices/lis/researchcourse/develop_writing_data_questionnaires.html

# CS7CS6 – Primary Data/ Secondary Data

Data that is experienced, observed or recorded by the researcher(s) are called **primary data**. Usually collected with a particular purpose in mind.

| Advantages | Disadvantages |
|---|---|
| Can tailor the data collected directly to you research question | Time consuming to collect and requires skill to collect the correct data |
| You own the data | Expensive to collect |
| | Need to be very careful about the collection instruments |
| | Need to protect the data |

**Secondary data** is data collected by someone other than the researcher. Can be used in conjunction with primary data.

| Advantages | Disadvantages |
|---|---|
| Easily obtained | May not be representative of your population |
| Usually Inexpensive | Data may need to be cleaned |
| Easily accessible | May be out of date |
| | Credibility needs to be checked |

# CS7CS6 – Checks on Secondary Data Sets

Are you allowed access to the data?
Are you allowed to analyse/use the data?
Are you allowed to report on your findings based on the data in publications/dissertation?
Is there a charge for using the data?
Does the data match what you need- be careful about definition of fields?
Does the data match the population you are interested in?
Can you appropriately strip out the data that you are interested in?
What specific variables are used in the data?
Who collected the data? Is it a reputable organisation?
How was the data collected?- particularly important if you are doing comparisons.
When was the data collected – Have collection methods remained constant over time
Are there any publications available about the data?
Is the data credible?

# CS7CS6 – Observations

Observation involves recording the behavioural patterns of people, objects and events in a systematic manner. Use when trying to understand complex contexts, group contexts. Can be used in conjunction with other methods. Observation is not limited to the visual sense- e.g. you could observe noises

Observational methods may be: structured-unstructured, disguised-undisguised, natural-contrived, personal- mechanical, NonParticipant-participant(ethnography).

| Advantages | Disadvantages |
|---|---|
| Provides opportunity to identify context | May be expensive |
| Good when you are trying to understand complex environments that are hard to describe in other ways | Hawthorn Effect |
| Good to use in conjunction with other methods e.g. observing someone using a new technology | What happens during the observation session may not be typical |
| Good for understanding what is happening in groups | Careful planning is required |
| Flexibility to collect unexpected data | Observer needs observation and domain skills and understanding |
| Useful for capturing differences between what people do and what they say/think they do. | There may be too much/too little to observe. |

# CS7CS6 – Focus Groups

Focus groups involve a group focusing on a particular topic. It is a technique that can be used to collect data which easily comes to light when people interact with each other. It is useful for focusing on a very specific topic. The participants should be able to engage quickly and have time to express all they know about the topic in a short time frame.

Focus groups usually consist of between 8-10 people who have something in common relevant to your research. It involves techniques of interviewing, facilitation and observation

| Advantages | Disadvantages |
| --- | --- |
| Can collect a lot of information quite quickly | Requires a suitable location |
| It is possible to record the interactions | Good facilitation skills required- may be some dominant/reticent participants. |
| Can answer concerns or provide clarity for potential participants | Time consuming to analyse the data collected |
| You can show artefacts e.g. devices, user interfaces, diagrams | Participants are self selecting |
| Potential for further engagement. | Need to be careful that group consensus doesn't develop. |

# CS7CS6 – Experiments

A description of 5 different types of experiments in computer science

1. Feasibility Experiment
2. Trial Experiment
3. Field Experiment
4. Comparative Experiment
5. Controlled Experiment



Experiments in Computing: A Survey- https://www.hindawi.com/journals/tswj/2014/549398/

# CS7CS6 – 5 Types of CS Experiments

**Type 1 "3.1. Feasibility Experiment**

The first and loosest use of the term "experiment" can be found in many texts that report and describe new techniques and tools. Typically, in those texts, it is not known if task  can be automated efficiently, reliably, feasibly, cost-efficiently, or by meeting some other simple criterion. A demonstration of experimental (novel, untested, and newly implemented) technology shows that it can indeed be done. Including the terms "demonstration" and "experimental" in the same sentence may sound like a forced marriage of two incompatible concepts, but in the computing literature "experiment" is indeed sometimes used nearly synonymously with "demonstration," "proof of concept," or "feasibility proof" as the following examples demonstrate.

Hartmanis and Lin [86, pages 213-214] wrote that in computer science and engineering theories develop over years of practice, with "experiments largely establishing the feasibility of new systems." Plaice [99] wrote, in ACM Computing Surveys, that the development of large software systems exemplifies experimentation in computer science—"and experimentation is the correct word, because we often have no idea what these tools will offer until they are actually used." He continued to describe that what constitutes an experiment is that a scientist "carefully defines what must be done and then carefully sets out to do it." Feitelson [79] identified the "demonstration of feasibility" view as one of the three common views to experimental computer science. Feitelson also noted that the "demonstration of feasibility" experiments in applied computer science are largely divorced from theoretical computer science [79].

The ACM FCRC Workshop on Experimental Computer Science (http://people.csail.mit.edu/rudolph/expcs.pdf(retrieved January 30, 2013)) involved "experimental engineering" that produces new "techniques, insights, and understanding that come from building and using computer systems." Hartmanis [85], though, wanted to make the difference between experiments and demonstrations explicit, calling for computing researchers to acknowledge the central role of demonstrations in the discipline. In their description of experimental computer science Basili and Zelkowitz [60], too, criticized the "demonstration" view of experimentation in computing: "experimentation generally means the ability to build a tool or system—more an existence proof than experiment."

Excerpt from Experiments in Computing: A Survey- https://www.hindawi.com/journals/tswj/2014/549398/

# CS7CS6 – 5 Types of CS Experiments

**Type 2 “3.2. Trial Experiment**

The second use of the term “experiment” in computing goes further than demonstrations of feasibility. The trial experiment evaluates various aspects of the system using some **predefined set of variables**. Typically, in those studies, it is not known how well a new system meets its specifications or how well it performs. A trial (or test, or experiment) is designed to evaluate (or test, or experiment with) the qualities of the system . Those tests are often laboratory based but can also be conducted in the actual context of use with various limitations.

Of Gustedt et al.’s [59] four-way categorization of experiments (in situ experiments, emulation, benchmarking, and simulation), the ones that permit the most abstraction—emulation, simulation, and benchmarking—fall into the trial experiment category. Emulation runs a real application in a model environment, simulation runs a model (limited functionality) application in a model environment, and benchmarking evaluates a model application in a real environment [59]. Similar “toy-versus-real” distinctions are made in descriptions of experimentation in software engineering [100].

McCracken et al. [41] wrote that experimental research is about “not only the construction of new kinds of computers and software systems, but also the measurement and testing” of those systems. Furthermore, trial experiments are not a privilege of the applied side of computing. Glass [47] proposed that formal theory needs to be validated by experiments, and Fletcher [87] wrote that theoretical computer scientists may “resort to trial runs because the problem is mathematically intractable.” Many types of validation of computational models of phenomena fall under trial experiments.”

Excerpt from Experiments in Computing: A Survey- https://www.hindawi.com/journals/tswj/2014/549398/

# CS7CS6 – 5 Types of CS Experiments

**Type 3 “3.3. Field Experiment**

A third common use of the term “experiment” is similar to trial experiments in that it is also concerned with evaluating a system’s performance against some set of measures. However, the field experiment takes the system out of the laboratory. Typically, in those studies, it is not known how well a system fulfills its intended purpose and requirements in its **sociotechnical** context of use. The system is tested in a live environment and measured for things such as performance, usability attributes, or robustness. The term “field experiment” is used in, for instance, information systems [101], while Gustedt et al. [59] used the term “in situ experiments”: real applications executed at the real scale using real hardware.
The experimental computer science debates involve various examples of field experiments. A robot car race is an oft-used example of a field experiment, or “experimentation under real-world conditions” [58]. In the DARPA Grand Challenge, driverless vehicles compete with each other in finding their way through various types of environments. A common downside to the field experiment is diminished reproducibility that is brought about by the large number of variables and limited control in live environments. Yet, as they are often quasi-experiments or limited-control experiments, field experiments offer more control than case studies or surveys do [101].”

Excerpt from Experiments in Computing: A Survey- https://www.hindawi.com/journals/tswj/2014/549398/

# CS7CS6 – 5 Types of CS Experiments

**Type 4 “3.4. Comparison Experiment**

A fourth common use of the term “experiment” refers to comparison between solutions. Many branches of computing research are concerned with looking for the **“best” solution for a specific problem** [87] or developing a new way of doing things “better” in one way or another. Typically, in reports of those studies, it is not known if (or rather, “not shown that”) system  outperforms system  with data set  and parameters . An experiment is set up to measure and compare  and , and the report shows that the new system beats its predecessors in terms of a set of criteria . Johnson [10] called that type of experimental analysis “horse race papers.” Fletcher [87] argued that many brands of experimental computer science are most applicable to that type of research (Fletcher referred to [45, 47]).
However, although comparison experiments seem “objective” in many ways, they are, in fact, susceptible to bias in a number of ways [79, 102]. It has been noted that often such experiments do not follow the standard precautions against experimenter bias, such as the blinding principle [87]. The researcher should not be able to choose , , , or  favorably for his or her own system . Zelkowitz and Wallace [28, 29] argued that “All too often the experiment is a weak example favoring the proposed technology over alternatives.” There again, many fields of computing have introduced standard tests, input data, and expected outputs, against which competing solutions can be compared (e.g., [103]).”



Excerpt from Experiments in Computing: A Survey- https://www.hindawi.com/journals/tswj/2014/549398/

# CS7CS6 – 5 Types of CS Experiments

**Type 5 "3.5. Controlled Experiment**

A fifth common use of the term "experiment" refers to the controlled experiment. The controlled experiment is the gold standard of scientific research in many fields of science—especially when researchers aim at eliminating confounding causes—and it typically enables generalization and prediction. There are numerous uses for the controlled experiment setup; for instance, it is often used for situations where it is not known if two or more variables are associated.
In many arguments for experimental computer science, by "experiment" the author explicitly or implicitly means "controlled experiment" but not always for the same reasons. Peisert [104] advocated controlled experiments for research on computer security, and their vision was that it promotes increased generalizability and better justified claims about products. Morrison and Snodgrass [71] wanted to see more generalizable results in software development. Schorr [105] argued that software and systems, with their increased user interaction, have grown too large for other kinds of methods but controlled experiments. Curtis [106] and Pfleeger [107] emphasized the role of controlled experiments in software engineering due to their potential for probabilistic knowledge about causality and increased confidence about what exactly in technical interventions caused the change. Feitelson [108] promoted evaluations under controlled conditions for all applied computer science."

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# CS7CS6 – Common Phases of Research Process

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That’s All Folks
Thank You for Listening