



Edinburgh Napier
UNIVERSITY

School of Computing,
Engineering & the
Built Environment

Research Methods in Computing:



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Dr. Khristin Fabian

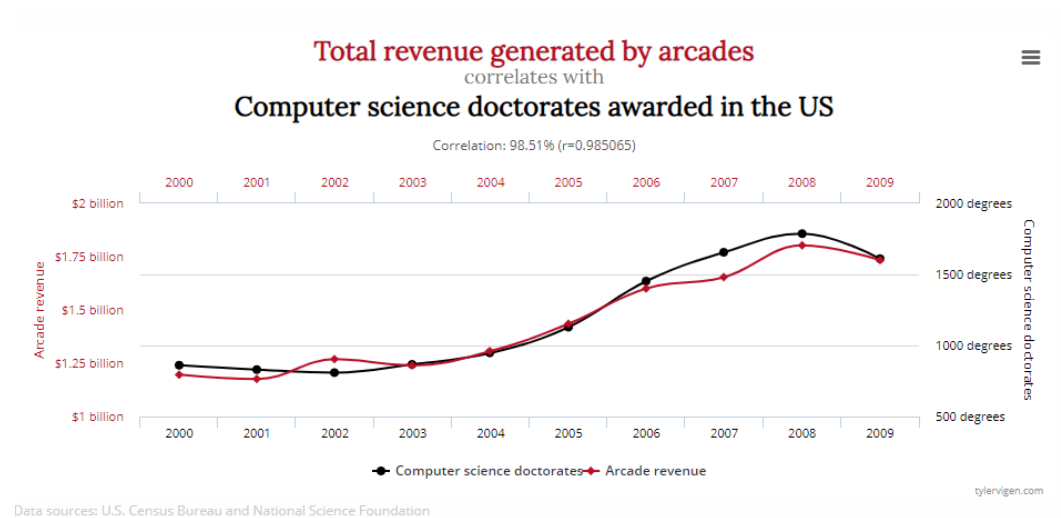
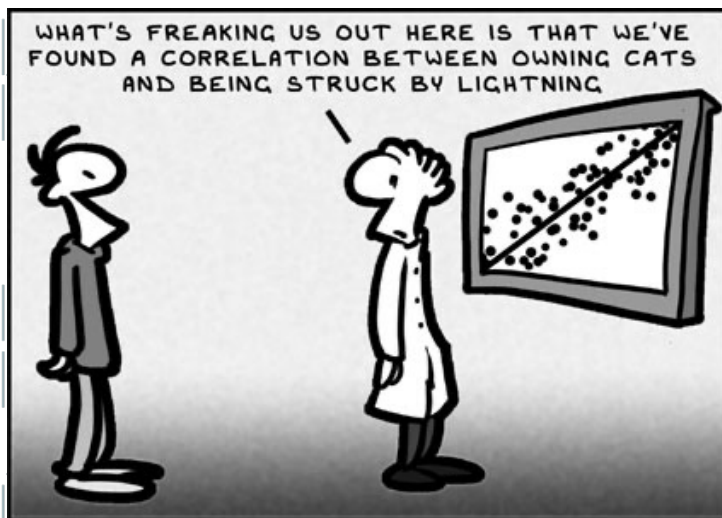


In this session we will discuss:

- Research and research methodologies
- Designing surveys
- Designing an experiment

What is research?

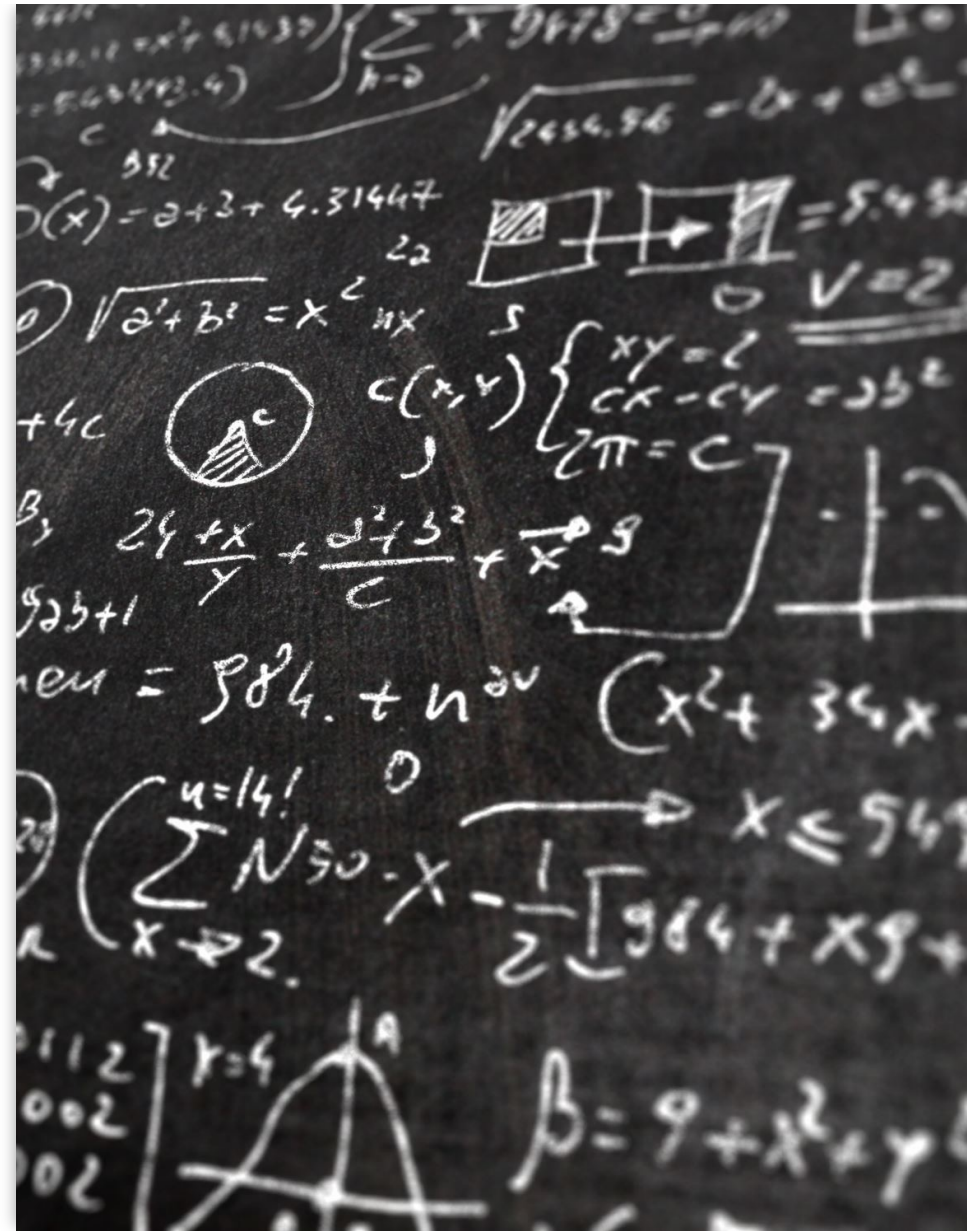
- We can define research as an activity of **systematic** enquiry that seeks answers to a problem.



<http://www.tylervigen.com/spurious-correlations>

What is research?

- the **systematic investigation** into and study of materials and sources in order **to establish facts and reach new conclusions**' (Oxford Dictionary)
- a **systematic process of investigation**, the general process of which is **to contribute to the body of knowledge that shapes, guides academic practice and / or practice disciplines** (Tarling & Crofts, 1998)



Classifying research

■ Field

- Position of the research within a hierarchy of topics:

ACM <https://dl.acm.org/ccs>

Speech Recognition < Natural Language Processing < Artificial Intelligence

Virtual Reality < Interaction Paradigms < Human Computer Interaction

■ Purpose

- Theoretical/Fundamental research
 - To increase understanding
- Applied research
 - To bring about change / solve concrete real-world problems

Classifying research

- Nature
 - theoretical
 - formal theory
 - simulation
 - observational
 - exploratory studies
 - descriptive studies
 - machine learning
 - experimental
 - applied research
 - applied experimentation
 - applied observational study

Edgar, T. W., & Manz, D. O. (2017). *Research methods for cyber security*. Syngress.

Theoretical/Fundamental Research

- **Theoretical research** is a logical exploration of a system of beliefs and assumptions.
- Purpose: to increase understanding (ideally, by developing new theory or scrutinizing existing theory),
 - In Cybersecurity: This type of research includes theorizing or defining how a cyber system and its environment behave and then exploring or playing out the implications of how it is defined.
 - Theoretical computer Science: This area explores the fundamental and foundational aspects of computers and computation. Aiming to improve understanding of computation and its capabilities, limitations and future potential, this research area encompasses research around logic and semantics, and the study of algorithms, complexity and automata (UKRI, 2025)

Observational Research

- This type of research is best to answer open-ended or comparatively broad research questions.
- **observational research** methods include sensing of real-world environments and data mining for discovery of interesting artifacts.
 - Observational research is useful when you are trying to understand a real cyber system (and the associated technosocial behavior).

Edgar, T. W., & Manz, D. O. (2017).

Observational Research

- **Exploratory Studies**
 - consist of collecting, analyzing, and interpreting observations about known designs, systems, or models, or about abstract theories or subjects
- **Descriptive studies**
 - focuses in depth on a specific case of some system
- **Machine learning**
 - looks at using computational algorithms to turn empirical data into usable models.

Edgar, T. W., & Manz, D. O. (2017).

Machine Learning

■ Cybersecurity

- Machine learning algorithms can be used to
 - (a) gather understanding of the cyber phenomenon that produced the data under study,
 - (b) abstract the understanding of underlying phenomena in the form of a model,
 - (c) predict future values of a phenomena using the above-generated model, and
 - (d) detect anomalous behavior exhibited by a phenomenon under observation.

Edgar, T. W., & Manz, D. O. (2017).

Experimental Research

- This is the type of research where a scientist takes concepts and beliefs gained from observation and theorizing and creates targeted, controlled experiments in an attempt to generate evidence in support of, or in contradiction, to their premise.

Edgar, T. W., & Manz, D. O. (2017).

Applied Research

- Applied research is the process of quantifying how well we applied the knowledge we have learned from basic science to solving some problem.
- Purpose: “deliberately intended to bring about social change” (Babbie, [2013](#), p. 18) and to solve concrete real-world problems.

Edgar, T. W., & Manz, D. O. (2017).

Applied Research

- Applied Experimentation
 - Benchmarking is the process of using a set of atomic test cases to evaluate the effectiveness of a solution.
 - Validation testing, on the other hand, is for evaluating solutions in controlled environments to see how they behave under varied but realistic conditions.
- Applied Observational Study
 - Applied exploratory
 - Applied descriptive

Edgar, T. W., & Manz, D. O. (2017).

Classifying research

- Research Approach
 - Quantitative
 - Qualitative
 - Mixed

Creswell and Creswell (2022)

Common Research Strategies

- Survey
- Design and creation
- Experiments
- Case studies
- Action research
- Ethnography

Surveys

- Aim: to obtain the same kinds of data from a large group of people (or series of events), in a standardized and systematic way.
 - Sampling technique
 - Random sampling
 - Purposive sampling
 - Snowball sampling

Design and creation

- The design and creation research strategy focuses on developing new technology products, also called artefacts (constructs, models, methods or instantiations)
- In computing, the research involves **analysing**, **designing** and **developing** a computer-based product.
- These projects explore and exhibit the possibilities of digital technology. For such projects to be considered as research, rather than only an illustration of technical prowess, they should demonstrate not just technical skills but also academic qualities such as analysis, explanation, argument, justification and critical evaluation.

Oates et al. (2022).

Experiments

- an experiment is a strategy that investigates cause and effect relationships, seeking to prove or disprove a causal link between a factor and an observed outcome.
- Hypothesis: Python is an easy language to learn compared to Java.
- Hypothesis: students attend lectures more frequently if you don't post handouts in advance.

Experimental Designs

- One group pre-test, post-test
- Static group comparisons
- Pre-test/post-test control group

Oates et al. (2022).

Case studies

- focuses on one instance of the ‘thing’ that is to be investigated
- This one instance, or case, is studied in depth, using a variety of data generation methods
- The aim is to obtain a rich, detailed insight into the ‘life’ of that case and its complex relationships and processes

Oates et al. (2022).



Data Collection Methods

- Interviews
- Observations
- Questionnaires
- Documents

What is wrong with this survey questionnaire?

Scenario: Evaluating a software application for educational use.

Respondents: Students and teachers

1. Did you find the software easy to use and useful?

Strongly
Disagree

Disagree

Neither
agree nor
disagree

Agree

Strongly
Agree

2. I did not eagerly anticipate to use the software.

Strongly
Disagree

Disagree

Neither
agree nor
disagree

Agree

Strongly
Agree

3. . It was to easy incorporate the use of the software with my instructional design ideas.

Strongly
Disagree

Disagree

Neither
agree nor
disagree

Agree

Strongly
Agree

4. How often did you use the software in class?

Never

Seldom

Sometimes

Frequently

Always

5. Did you enjoy using the math game in class?

Never

Seldom

Sometimes

Frequently

Always

6. What do you think is the best feature of this software?

How to design a bad survey instrument

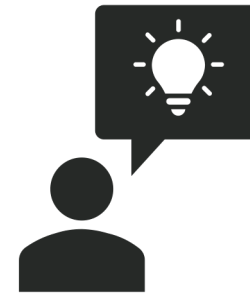
1. Create a leading or biased question
2. Use double-barrelled questions
3. Vague questions
4. Negatively worded questions
5. Acronyms, Nonspecific or unfamiliar terms
6. Incomplete range or overlapping answer choices
7. Absolute answers *always
8. Responses that do not match questions
9. Not pretesting/piloting the survey
10. Excessively long survey

(Sullivan & Artino, 2017)

Designing an experiment



You have designed a software
that grades student essays



Think of ways of evaluating
the software...

Resources

- Creswell, J. W., & Creswell, J. D. (2022). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.
- Edgar, T. W., & Manz, D. O. (2017). *Research methods for cyber security*. Syngress.
- Oates, B. J., McLean, R., & Griffiths, M. (2022). Researching information systems and computing.
- Sullivan, G. M., & Artino Jr, A. R. (2017). How to create a bad survey instrument. *Journal of graduate medical education*, 9(4), 411-415.