

Research, Engineering, & Design

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Lecture notes in this series are based on

- Ahmed Sabbir Arif. 2021. [Statistical Grounding](#). *Intelligent Computing for Interactive System Design: Statistics, Digital Signal Processing, and Machine Learning in Practice*, ACM
- Ann Blandford, Dominic Furniss, Stephann Makri. 2016. [Qualitative HCI Research: Going Behind the Scenes](#). Morgan & Claypool
- Jonathan Lazar, Jinjuan Feng, Harry Hochheiser. 2017. [Research Methods in Human-Computer Interaction](#). Morgan Kaufmann
- I. Scott MacKenzie. 2013. [Human-Computer Interaction: An Empirical Research Perspective](#), Morgan Kaufmann
- Interaction Design Foundation. 2022. [Design Thinking](#)
- Lecture notes of [Amy Bruckman](#), [Mark Dunlop](#), [Niels Henze](#), [I. Scott MacKenzie](#), [Laura Moody](#), [Albrecht Schmidt](#), [Kami Vaniea](#)

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Engineering & Design

- Researchers, engineers, and designers often work closely with each other, but the skills each bring are different
- Engineers and designers build things
 - They bring together the best in form and function:
 - **Form** emphasis on design
 - **Function** emphasizes on engineering
- There is a tension, even trade-off, between form and function
 - Too much focus on form affects function and vice versa?



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Engineering & Design: Form vs. Function



- **Form follows function:** Louis Sullivan (1856–1924)
 - A design principle that states the shape of an object should primarily relate to its intended function or purpose

The Wainwright Building is a 10-story terra cotta office building at 709 Chestnut Street in downtown St. Louis, Missouri. The Wainwright Building is considered to be one of the first aesthetically fully expressed early skyscrapers. It was designed by Dankmar Adler and Louis Sullivan and built between 1890 and 1891.



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Engineering & Design: Form vs. Function



- Form over function?
- Good design is astatically pleasing
 - In visual terms, aesthetics includes factors such as balance, color, movement, pattern, scale, shape and visual weight, etc.

David Gewirtz. Apple's obsession of form over function is hitting some folks in the face (literally). Feb. 20, 2018. ZDNET. <https://www.zdnet.com/article/apples-obsession-of-form-over-function-is-hitting-some-folks-in-the-face-literally>

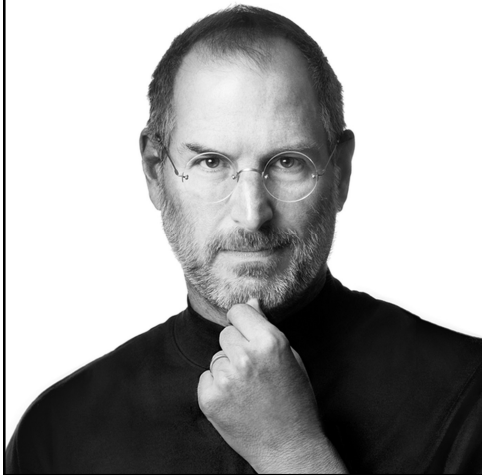


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Engineering & Design: Form vs. Function

- Maintain a balance between the two



“Design isn’t just what it looks like and feels like – design is how it works”
Steve Jobs



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Engineering & Design: Focus on Form?

- There is a tension, even trade-off, between form and function
 - Too much focus on form affects function and vice versa?



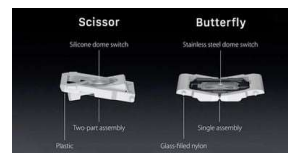
The form is elegant – smooth, shiny, metallic

Problem?

No tactile sense at the sides of the touchpad



Duct tape!



Dieter Bohn. 2020. [The Saga of Apple's Bad Butterfly MacBook Keyboards is Finally Over](#). The Verge



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Engineering & Design: Focus on Function?



Volkswagen Beetle (1938–2003): A cheap and simple mass-produced “people’s car”



The BIC Cristal: Inexpensive, disposable pen mass-produced starting 1950 in France. It is the best-selling pen in the world



Lemon Squeezer: The oldest date to early 18th century in Turkey



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Research

Research means different things to different people
Often just a word to add weight to an assertion



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CRACK THE CODE OF YOUTH
REVEAL YOUNGER-AGING SKIN

NEW
YOUTH CODE
YOUTH REGENERATING
PRE-ESSENCE

IN 1 DROP: MORE RADIANT
SKIN IS MOISTURIZED,
SOFT AND SMOOTH

IN 1 DROP: MORE REFINED
SKIN QUALITY IS
VISIBLY IMPROVED

IN 1 DROP: REVULNERATED SKIN
SKIN LOOKS DRAMATICALLY YOUNGER

Because you're worth it.
L'OREAL PARIS

After 10 years of research, L'Oréal Laboratories discovered that the recovery genes in younger skin react 5X faster to skin damage than aged-up skin.

Have Youth Code Pre-essence, an extraordinary formula with PRO-GEN™ technology, scientifically designed to speed up skin's recovery power to melt as it did when you were younger.

“After 10 years of research
L'Oréal Laboratories discovered
that...”

Is this research available for public scrutiny?
What about the independence of the research?

L'Oréal Settles FTC Charges Alleging Deceptive Advertising for Anti-Aging Cosmetics, June 30, 2014

[Claims that Skincare Products Targeted Users' Genes Were Misleading - FTC Says](#)

L'Oréal Youth Code advertisement

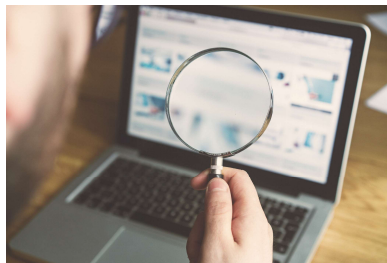
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il
inclusive
interaction lab

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Research: Definition 1

Careful or diligent search



Example: Searching a computer to find all files modified on a certain date

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Research: Definition 2

Collecting information about a particular subject



Examples:

Survey voters in advance of an election

Collect information on users' computer habits (the number of times they... consulted the manual, clicked the wrong button, uttered an expletive, etc.)



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Research: Definition 3

Investigation or experimentation aimed at the discovery and interpretation of facts, the revision of accepted theories or laws considering new facts



Example: Design and conduct a user study to **test** whether a new interaction technique improves on an existing interaction one

Tafadzwa Joseph Dube, Kevin Johnson, Ahmed Sabbir Arif. 2022. [Shapeshifter: Gesture Typing in Virtual Reality with a Force-based Digital Thimble](#). In CHI Conference on Human Factors in Computing Systems Extended Abstracts (CHI EA 2022). ACM, New York, NY, USA, Article 230, 1–9.



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Research: Experimentation

- A central activity in HCI research
- An experiment is sometimes called a *user study*
- Not to be confused with *usability evaluation*
- Formal, standardized methodology preferred
 - Brings consistency to a body of work
 - Facilitates reviews and comparisons between different user studies



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Research: Must Be Reproducible

- Research that cannot be replicated is useless
- A high standard or reproducibility is essential
- The research write-up must be sufficiently detailed to allow a skilled researcher to replicate the research if he/she desired
- The easiest way to ensure reproducibility is to follow a standardized methodology



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Research: Facts, Theories, & Laws

- Facts
 - Building blocks of evidence
 - Evidence is used to test hypotheses
- Theory
 - An hypothesis assumed for the sake of argument
 - A scientifically accepted body of principles that explain phenomena
- Law
 - More constraining, more formal, more binding
 - A relationship that is invariable under given conditions
 - HCI involves humans, so laws are of questionable value



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Research: Fitts' Law

- HCI's best known "law"
- Fitts proposed a model, not a law
- Fitts' law is a behavioral, predictive, and descriptive model of human motor behavior
- It is a "law" only in that other researchers took up the label as a celebration of the robustness and importance of Fitts' work



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Research: Milieu

- Unlike engineering & design, research is not about products
- Research is narrowly focused
 - Research questions are small in scope
- Research is incremental, not monumental
 - Research ideas build on previous research ideas
- Good ideas are refined, advanced (into new ideas)
 - Bad ideas are discarded, modified
- Products come much later (the long nose of innovation)



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Research: Questions

- We conduct empirical research to answer and raise questions about UI designs or interaction techniques
- Consider the following questions:
 - Is it viable?
 - Is it better than current practice?
 - Which design alternative is best?
 - What are the performance limits?
 - What are the weaknesses?
 - Does it work well for novices?
 - How much practice is required?



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Research: Testable Questions

- Preceding questions, while unquestionably relevant, are not testable
- Try to re-cast as testable questions (even though the new question may appear less important)
- Scenario...

You have invented a new text entry technique for smartphones, and you think it's pretty good. In fact, you think it is better than the Qwerty. You decide to undertake a program of empirical enquiry to evaluate your invention. What are your research questions?



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Research: Testable Questions

- Very weak
 - *Is the new technique any good?*
- Weak
 - *Is the new technique better than Qwerty?*
- Better
 - *Is the new technique faster than Qwerty?*
- Even better
 - *Is the measured entry speed (in words per minute) higher for the new technique than for Qwerty after one hour of use?*



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Research: Designers' Dilemma

- Gaver & Bowers opine on the struggle for designers to also be researchers:
 - *Do we add research questions or methodological rigor to design practice?*
 - *Do we change design practices to make contributions look more like research?*
 - *Is the result still design, or have we lost something in the process?*
 - *The problem is novel products alone do not seem sufficient to count as research*



Photostroller designed for use by residents of a care home for older people. It shows a continuous slideshow of photographs using a set of six predefined categories.

Bill Gaver, John Bowers. 2012. Annotated Portfolios. interactions 19, 4: 40–49.



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User Experience Design

- User Experience Design (UX) is a holistic approach in designing the experience a person will encounter when interacting with a:
 - Device
 - System
 - Application
- It considers user interface design in the broader context of use



A UX designer focuses on why, what, and how of product used to create meaningful experiences.



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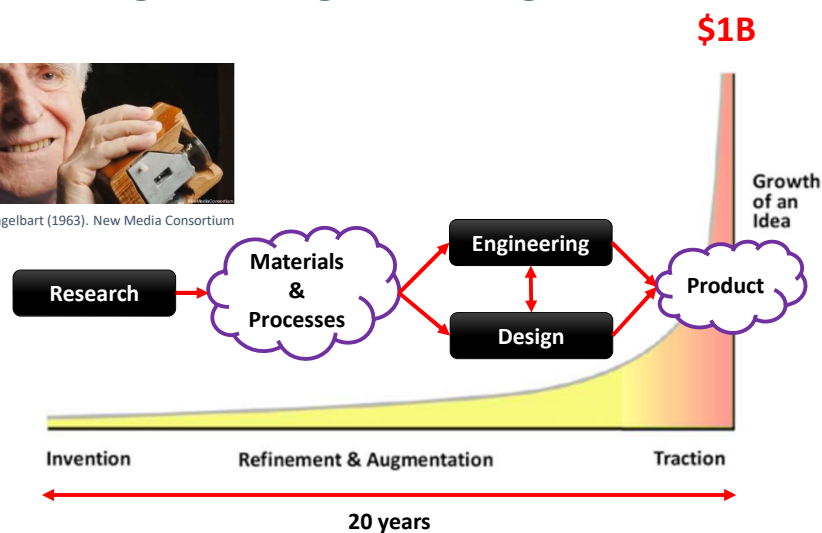
User Study vs. Usability Evaluation

Feature	User Study	Usability Evaluation
Manipulated variable(s)?	Yes	No
Research method	Experimental	Observational
Place in timeline	Early	Late
Level of inquiry	Low	High

Research, Engineering, & Design



Doug Engelbart (1963). New Media Consortium



Bill Buxton. 2018. [The Long Nose of Innovation](#). Business Week.

Empirical Investigation



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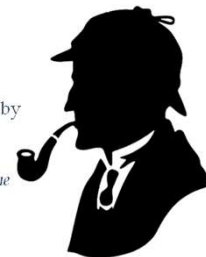
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Empirical Research

- Empirical:
 - Originates in or based on observation or experience
 - Relies on experience or observation alone without due regard for system or theory
 - Don't be blinded by pre-conceptions
 - Capable of being verified or disproved by observation or experiment

"It is a capital mistake to theorize before you have all the evidence. It biases the judgment." Sherlock Holmes in A Study in Scarlet (1887) by Arthur Conan Doyle

"when you have eliminated all which is impossible, then whatever remains, however improbable, must be the truth." Sherlock Holmes in The Blanched Soldier (1926) by Arthur Conan Doyle



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Empirical Research: Example

- Nicolas Copernicus (1473-1543)
 - Prevailing system or theory: celestial bodies revolved around the earth
 - Copernicus made astronomical observations that cut against this view
 - Result: *heliocentric cosmology – earth & planets revolve around the sun*
- HCI research:
 - Framed by hypotheses
 - Methodology to test hypotheses
 - Experiments (or user studies) are the vehicle
 - Hypotheses must be sufficiently narrow and clear to allow for verification or disproof



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Research Methods

Observational, correlational, and experimental



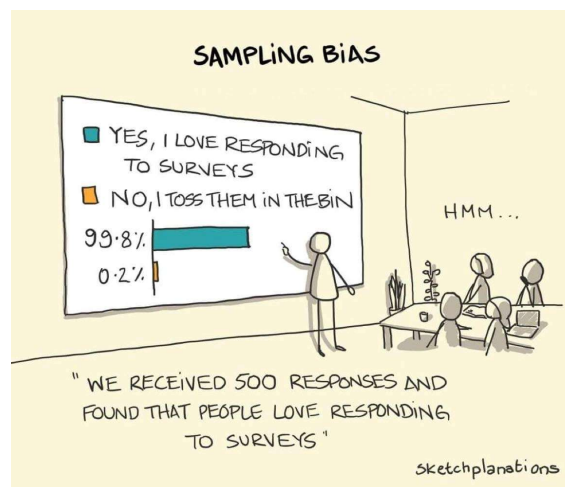
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Observational Method

- Example techniques:
 - Interviews, field investigations, contextual inquiries, case studies, field studies, focus groups, think aloud protocols, story telling, walkthroughs, cultural probes, etc.
- HCI approach: *usability evaluation*
- Focus on qualitative assessments (cf. quantitative)
- Relevance vs. precision
 - High in relevance (behaviours studied in a natural setting)
 - Low in precision (lacks control available in a laboratory)
- Goal: discover and explain reasons underlying human behaviour (*why* or *how*, as opposed to *what*, *where*, or *when*)

Observational Method



Correlational Method

- Look for relationships between variables
- Observations made, data collected
 - Example: Are user's privacy settings while social networking related to their age, gender, level of education, employment status, or income?
- Non-experimental
 - Interviews, on-line surveys, questionnaires, etc.
- Balance between relevance and precision (some quantification, observations not in lab)
- Cause-and-effect conclusions not possible

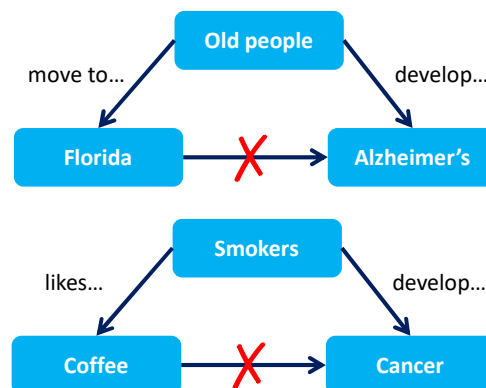


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Correlational Method

- Correlation is not causation: two variables moving together does not necessarily mean one variable causes the other to occur



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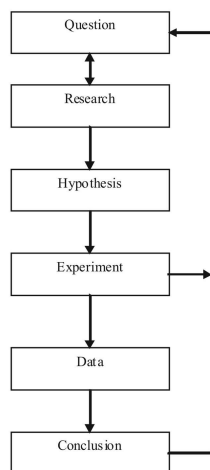
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Experimental Method

- Aka *scientific method*
- Controlled experiments conducted in lab setting
- HCI approach: *user study*
- Relevance vs. precision
 - Low in *relevance* (artificial environment)
 - High in *precision* (extraneous behaviours easy to control)
- At least two variables:
 - *Manipulated variable* (aka *independent variable*)
 - *Response variable* (aka *dependent variable*)
- Cause-and-effect conclusions possible (changes in the manipulated variable *caused* changes in the response variable)

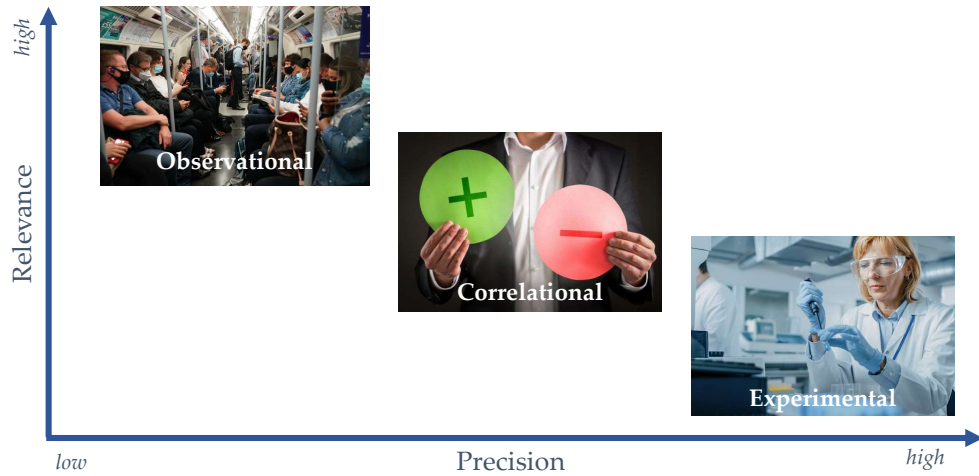
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Experimental Method



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Relevance vs. Precision



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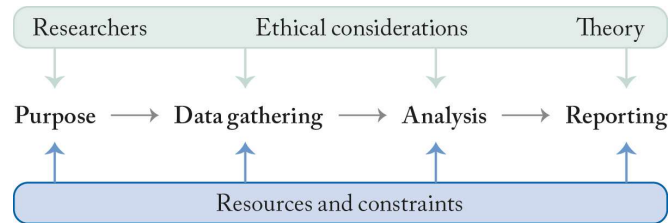
Research Framework

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PRETAR (PRET A Reporter) Framework



- **P**urpose of the study
- **R**esources and constraints
- **E**thics
- **T**echniques for data collection
- **A**nalysis techniques
- **R**eport findings

Ann Blandford, Anne Adams, Simon Attfield, George Buchanan, Jeremy Gow, Stephann Makri, Jon Rimmer, Claire Warwick. 2008. [The PRET A Reporter Framework: Evaluating Digital Libraries from the Perspective of Information Work](#). Information Processing & Management 44, 1, 4-21.

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