

Research Methodology



Research as opposed to investigation

- A research document advances knowledge, the field of study or activity.
- It contributes to the expansion of knowledge and understanding on a highly specific topic in a certain field.

Discovery or invention

- Computer scientists, researchers in nanotech, researchers in process engineering or in industrial engineers are inventors

Discovery or invention

- Software computer science produces *inventions*
- Computers do not exist by themselves. They have been created by human beings => there is nothing to *discover* in a computer or in a software
- The objective of research in CS is “just” to make computers and computer networks more efficient more easy to use, more reliable, more powerful... i.e. more useable/useful
- As a consequence, a research result in CS has no (real) intrinsic value. It has only the value that the research community and/or the society gives to it. A useless invention has no value !

SCIENTIFIC RESEARCH

- Research can be defined as *the search for knowledge*, or as any *systematic investigation*, with *an open mind*, to establish novel facts, solve new or existing problems, prove new ideas, or develop new theories.

What Is Research?

- “A combination of investigation of past work and effort in the present that will help others in the future”
- A set of opposites
 - Fun and frustration
 - Small steps and large insights
 - Building on others’ work and contributing your own work
- Finding or developing something new that changes the world....

Key take home messages about Research

- Research:
 - Should be about some problem that encourages enthusiasm (for you) and interest (for others)
 - Is often generated from the thought “what we’ve got now/from the past isn’t quite right/good enough – we can do better...”
 - Consists of work that leads to a meaningful contribution
 - Generates, in some way, a better solution to the problem

Purposes of a Research:

- To discover facts and ideas not previously known
- To test existing theories and explanations for various issues and subjects
- To achieve better and more complete understanding of something
- To find causes behind specific occurrences and events
- To discover new techniques and methods for things if existing one are not yielding satisfactory results
- To improvise and redefine a product to increase sales, and many more.....

Research Types

- Quantitative vs. Qualitative Research
 - Quantitative – use of statistical, formulaic or numerical analysis to generate results
 - Main approach: analysis; causal determination, prediction, generalization of findings
 - Results: “This solution is N% better”
 - Qualitative – not quantitative; use of non-numeric techniques
 - Main approach: discovery; illumination, understanding, extrapolation to similar circumstances
 - Results: “This is a new way of solving our problem”

Who Does Research?

- Graduate Students
 - Masters Degree (lower standard)
 - Ph.D. Degree (higher standard)
- Researchers at universities
 - Post-Doctoral students
 - Faculty members
- Researchers in industry
 - Research scientists
 - Many other technical workers
- Undergraduate students (like you)

Who Does Research? (2)

- Individuals
- Teams
- Teams almost always make the process easier
 - Division of labor
 - Feedback from team members
 - Each member can work to own strengths

The Traditional Scientific Method:

Observation of selected parts of nature-----Explanation and Critical analysis of the findings-----Formulation of hypothesis-----Verification through experimentation-----Fact/Knowledge generated.

Research Method based on the Scientific Method

- Initial Idea
- Background Investigation
- Refinement of Idea
- Core Work
 - Investigation and Development
 - Documentation
 - Prototype (if appropriate)
- Evaluation
- Identification of Future Work
- Presentation

Research Process – Initial Idea

- Stems from critical thinking
- Be on the lookout for and open to seeing problems
 - . Gaps in framework
 - . Repetitive behavior that's slightly different (and can be generalized)
 - . Manual solutions (that can be automated)
 - . Inelegant solutions
- Ask questions
 - . “Is something missing here?”
 - . “Can this be done in a better way?”
 - . “Is there a need for a new approach?”
- Should be an area you’re interested in, as:
 - . You’ll be spending a lot of time with it
 - . It won’t always be easy/fun to continue...

STEP 1: SEARCHING FOR A PROBLEM TO INVESTIGATE

Here are some guidelines (criteria) to help you select and define your problem:

- Is the problem important or significant? Is the question worthwhile for the expenditure of time, energy, and funds involved? What is its societal relevance?
- Can the problem be stated in question form? Finding the answer then becomes the objective of the study.
- Can the problem be delimited and narrowed? Can boundaries be defined?
- Are resources of information available and the state of the art practical?
- Does it interest you?
- Do you have the required background to undertake the inquiry under question?

After the Idea, develop a research problem and identify your purpose and create purpose statement(s)

Write a specific purpose statement to avoid deviation from the research objective.

Study the example below:

- **Problem:** What are the dietary needs of the elderly in nursing homes?
- **Purpose:** To determine the dietary needs of the elderly in nursing homes so as to better satisfy and treat them.

Research Process – Background Investigation

- Given an idea, need to determine:
 - Has this work been done previously?
 - What similar work has been done leading up to this point?
 - How is any previous work distinguished from what I'm planning to do?
 - What group of people will be positively impacted by the research?
- Tools
 - Literature Review using library resources (e.g. online databases such as ACM and IEEE, popular magazines)
 - WWW search

Research Process – Refinement of Idea

- Based on background investigation, need to refine idea
- Issues:
 - Precision – focus on precisely identifying:
 - Problem
 - Possible solutions (plural!)
 - Scope – need to “build fences”
 - What’s an essential part of this work? (fence in)
 - What’s tangential, additional, or for any other reason best left for later/someone else? (fence out)

Research Process – Core Work, Investigation and Development

- Provide yourself with infrastructure
 - equipment / software
 - additional knowledge (“get up to speed”)
- Do the work
 - Experimentation (scientific process)
 - Develop opinions
 - Look for better ways of solving problem
 - Can you generalize?
 - Can you develop a framework?
 - Discuss, brainstorm
 - Reevaluate as you proceed
 - Look for improvements, changes to your original ideas

Research Process – Core Work, Investigation and Development (2)

- Process
 - Work regularly
 - Easier to keep going if have a commitment to a regular work time
 - Helps you keep your past work in mind
 - Allocate large block of time for research
 - Takes time to get going/back to speed
 - Make sure can do something significant each work session

Research Process – Core Work, Documentation

Need to document as you go

- . Don't want to lose any information
- 1) Maintain a journal for day-to-day thoughts
 - . Can be paper, electronic, ...
 - . Keep it with you at all times
 - Never know when good ideas will hit
 - 2) Keep an updated task list
 - . Focus on accomplishing something each work session
 - 3) Write up your work
 - . Periodically, write a few pages on a subset of your work
 - Summarize work, accomplishments, problems
 - . At end, write up a summary document
 - Can be based on steps discussed here

Research Process – Core Work, Prototype

- Need to demonstrate the merit of your ideas
- If work is non-theoretical, do this through a developed system
 - No need to build the entire system
 - Just need to demonstrate the value of the core ideas

Research Process - Evaluation

Perhaps the most difficult part....

- . Best if can show others are already using your work
- Quantitative
 - . Test your prototype
 - . What improvements exist over currently available alternative?
 - . How much of an improvement do you see?
- Qualitative
 - . What can you do now that couldn't be done before?
 - . What are the benefits of your solution?

Research Process – Identification of Future Work

- Helps you organize any future efforts
- Helps others build on your work
- Sources:
 - What you excluded in your idea refinement
 - New problems that have surfaced during your work

Research Process - Presentation

- It's not a contribution to the field if no one knows about it or can use it
- Presentation/Dissemination
 - Conferences, Journals, Web
 - e.g. National Undergraduate Research conference
 - Papers, Talks, Poster Sessions
 - e.g. UWEC and UW System Research Days

Example

- my Master's project
- an example for each of you
 - choose a CS subject you're interested in
 - think of a problem or issue you see in that area
 - refine your interest to a possible project that involves one or more ways of solving that problem
 - outline the steps you'd take to do the project work and test your ideas
 - what is your hypothetical conclusion?
 - how would you evaluate the quality of your solution?