

What is 'research'?

Research (Dictionary)

Noun

- 1 Scholarly or scientific investigation or inquiry.
- 2 Close, careful study.

Verb

- 1 To study (something) thoroughly so as to present in a detailed, accurate manner.
(Example: researching the effects of acid rain.)

Note the difference between the definition of the noun and of the verb.

What is 'research'?

Study (Dictionary)

Noun

- ① The pursuit of knowledge, as by reading, observation, or research.
- ② Attentive scrutiny.

Verb

- ① To apply one's mind purposefully to the acquisition of knowledge or understanding of (a subject).
- ② To inquire into; investigate.
- ③ To examine closely; scrutinise.

What is 'research'?

Research (<http://en.wikipedia.org/wiki/Research>)

- an active, diligent, and systematic process of inquiry in order to discover, interpret or revise facts, events, behaviours, or theories, or to make practical applications with the help of such facts, laws, or theories.
- a collection of information about a particular subject.
- derives from the Middle French and the literal meaning is “to investigate thoroughly”.

Homework: Read the Wikipedia article!

Research Methods in Computer Science

Lecture 2: Research (continued)

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Previously ...

1 Introduction and Overview

- Aims
- Learning outcomes
- Delivery
- Assessment

2 What is 'Research' ?

Today ...

3 What is 'Research' ?

- More Definitions of 'Research'

4 Knowledge

- A Hierarchy
- Data
- Information
- Knowledge

5 Knowledge

- Theories

6 Originality

- Definition
- The importance of repeating the work of others

What is 'research'?

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Homework: Read the Wikipedia article!

What is 'research'?

Research (Higher Education Funding Council for England)

Original investigation undertaken in order to gain knowledge and understanding, including

- work of direct relevance to the needs of commerce and industry and to the public and voluntary sectors
- scholarship (research infrastructure)
- the invention and generation of ideas, images, performances and artifacts including design, where these lead to new or substantially improved insights;
- the use of existing knowledge in experimental development to produce new or substantially improved materials, devices, products and processes, including design and construction.

Knowledge: A hierarchy

Knowledge is a particular level in a hierarchy:

- 1 Data
- 2 Information
- 3 Knowledge
- 4 [Wisdom]

Knowledge: Data and Information

Datum/Data

- statements accepted at face value (a 'given') and presented as numbers, characters, images, or sounds.
- a large class of practically important statements are **measurements** or **observations** of variables, objects, or events.
- in a computing context, in a form which can be **assessed**, **stored**, **processed**, and **transmitted** by a computer.

Knowledge: Data and Information

Information

- **Data** on its own has no meaning, only when **interpreted** by some kind of **data processing system** does it take on meaning and becomes **information**

Example:

The **human genome project** has determined the sequence of the 3 billion chemical base pairs that make up human DNA

→ identifying base pairs produces **data**

→ **information** would tell us what they do!

Knowledge: Alternative definitions (1)

Knowledge (Dawson 2005)

- higher level understanding of things
- represents our understanding of the 'why' instead of the mere 'what'
- interpretation of information in the form of rules, patterns, decisions, models, ideas, etc.

In **natural sciences**, understanding 'why' is too ambitious most of time; understanding 'how' is usually what we aim for

In other areas, understanding 'how' is trivial, understanding 'why' is challenging

Knowledge: Alternative definitions (2)

Knowledge (Davenport et al. 1998)

- a fluid mix of **framed experience**, **contextual information**, values and **expert insight** that provides a **framework for evaluating and incorporating new experiences and information**.
- information combined with experience, context, interpretation, and reflection
- high-value form of information that is ready to apply to decisions and actions

Second point similar to last point in the previous definition

Last point seems to imply that knowledge has to be useful
(is astrophysics useful?)

Knowledge: Alternative definitions (3)

Knowledge (<http://en.wikipedia.org/wiki/Knowledge>)

- the **awareness** and **understanding of facts**, truths or information gained in the form of experience or learning (a posteriori), or through deductive reasoning (a priori)
- an appreciation of the possession of **interconnected details** which, in isolation, are of lesser value
- both knowledge and information consist of true statements, but knowledge is information that has a **purpose or use** (information plus intentionality)

Knowledge and theories: Definition

Scientific knowledge is often organised into **theories**.

Theory (<http://en.wikipedia.org/wiki/Theories>)

- a **logically self-consistent model** or framework describing the behaviour of a certain natural or social phenomenon, thus either originating from observable facts or supported by them
- formulated, developed, and evaluated according to the **scientific method**

Knowledge and theories: Criteria

Theory (<http://en.wikipedia.org/wiki/Theories>)

A body of (descriptions of) knowledge is usually only called a **theory** once it has a **firm empirical basis**, that is, it

- 1 is **consistent with pre-existing** theory to the extent that the pre-existing theory was experimentally verified, though it will often show pre-existing theory to be wrong in an exact sense,
- 2 is **supported by many strands of evidence** rather than a single foundation, ensuring that it probably is a good approximation if not totally correct,

Knowledge and theories: Criteria

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A body of (descriptions of) knowledge is usually only called a **theory** once it has a **firm empirical basis**, that is, it

- ③ **makes (testable) predictions** that might someday be used to disprove the theory, and
- ④ has **survived many critical real world tests** that could have proven it false,
- ⑤ is a/the **best known explanation**, in the sense of Occam's Razor, of the infinite variety of alternative explanations for the same data.

Knowledge and theories: Facts versus theories

‘This (e.g. evolution) is only a **theory** not a **fact**’

Fact

1. a **truth** (statement confirming to **reality**)
or
2. **data** supported by a **scientific experiment**

- Status of a ‘**truth**’ is by and large unachievable
- A **theory** is formulated, developed, and evaluated according to the **scientific method**

Given enough **experimental support** a **theory** can be
(a scientific) **fact**

Originality (1)

Research (HEFCE): Original investigation undertaken in order to gain knowledge and understanding

Originality

Doing something that has not been done before

Dawson (2005):

There is no point in repeating the work of others and discovering or producing what is already known

Only true for what is truly known (i.e. very little)

- Theories make predictions, which need to be tested
- The people performing those tests are neither infallible nor trustworthy
- Tests need to be repeated and results replicated

(In)Fallibility

Cold fusion

(http://en.wikipedia.org/wiki/Cold_fusion)

- **Cold fusion**: Nuclear fusion reaction that occurs well below the temperature required for thermonuclear reactions, that is, near ambient temperature instead of millions of degrees Celsius
- First reported to have been achieved by Pons (University of Utah) and Fleischmann (University of Southampton) in 1989
- Scientists tried to replicate their results shortly after initial announcement
- Teams at Texas A&M University and the Georgia Institute of Technology first confirmed the results, but then withdraw those claims due to lack of evidence
- Vast majority of experiments failed

Research Methods in Computer Science

Lecture 3: Research (continued)

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Research (Higher Education Funding Council for England)

Original investigation undertaken in order to gain knowledge and understanding

Today ...

- 7 Investigation
- 8 Knowledge
- 9 Originality
 - Areas of originality
- 10 Gain
- 11 What is 'Research' ?
 - Summary

Investigation

‘An active, diligent, and systematic process of inquiry’ (Wikipedia)

- Scientists use observations and reasoning to develop technologies and propose explanations for natural phenomena in the form of hypotheses
- Predictions from these hypotheses are tested by experiment and further technologies developed
- Any hypothesis which is cogent enough to make predictions can then be tested reproducibly in this way
- Once it has been established that a hypothesis is sound, it becomes a theory.
- Sometimes scientific development takes place differently with a theory first being developed gaining support on the basis of its logic and principles

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Information

- **Data interpreted** by some kind of **data processing system** which gives it meaning

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Research and Originality (2)

Areas of originality (Cryer 1996)

- Exploring the unknown
Investigate a field that no one has investigated before
- Exploring the unanticipated
Obtaining unexpected results and investigating new directions in an already existing field
- The use of data
Interpret data in new ways
- Tools, techniques, procedures, and methods
Apply new tools/techniques to alternative problems
Try procedures/methods in new contexts

Gain

Research (HEFCE): Original investigation undertaken in order to gain knowledge and understanding

Contribution

Research is supposed to add to the world's body of knowledge and understanding (in contrast to adding to the researcher's knowledge and understanding)

What is 'research'?

In summary, what are the **three key aspects of research**?

(10 minutes group discussion)

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Sharp et al. (2002)

Seeking through methodical process to add to one's own body of knowledge and to that of others, by the discovery of non-trivial facts and insights

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What is 'research'? (Summary)

Wikipedia	HEFCE	Sharp
active, diligent, and systematic process of inquiry	investigation	methodical process
discover, interpret, or revise		discovery
	gain	add
facts, events, behaviours, or theories	knowledge and understanding	knowledge / non-trivial facts and insights