COMP 516 Research Methods in Computer Science

Dominik Wojtczak

Department of Computer Science University of Liverpool

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Lecture 2: What is 'Research'?

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Research and experimental development (R&D) (Frascati Manual 2002)

"Creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications."

Basic research (Frascati Manual 2002)

"Experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view."

Applied research (Frascati Manual 2002)

"It is also original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective."

Experimental development (Frascati Manual 2002)

Systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed.

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Research (a maxim)

"Copying from one source is plagiarism, copying from several sources is research".

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 knowledge?
- How is knowledge acquired?
- To what extent is it possible for a given subject or entity to be known?

What is knowledge?

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Knowledge is a particular level in a hierarchy:

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

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.

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:

- where would tell us what they do!
- \rightsquigarrow wisdom would tell us what part of this knowledge is important to what we do!

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Example:

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

- videntifying base pairs produces data
- winformation would tell us what they encode!
- ~ knowledge would tell us what they do!
- \rightsquigarrow wisdom would tell us what part of this knowledge is important to what we do!
- In analogy to OSI model of networking: Physical layer, Data link layer, Presentation layer, Application layer

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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

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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, ready to apply to decisions and actions

Second point similar to last point in the previous definition

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

- awareness and understanding of facts, truths or information gained as experience or learning (a posteriori), or through deductive reasoning (a priori)
- 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)

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Knowledge: A Hierarchy

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Scientific knowledge is often organised into theories.

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- formulated, developed, and evaluated according to the scientific method

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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

- 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's probably a good approximation if not totally correct

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

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- 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 conforming 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

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- Scientists use observations and reasoning to 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 established that a hypothesis is sound, it becomes a theory
- Sometimes scientific development takes place differently with a theory first being developed on the basis of its logic and principles

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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

Those performing the tests are neither infallible nor trustworthy

Tests need to be repeated and results replicated

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- 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 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
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(Un)Trustworthiness

Jan Hendrik Schön

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- Researcher at Bell Labs working in the field of condensed matter physics and nanotechnology
- In 2001, he was listed as an author on an average of one research paper every eight days
- Claimed to have produced a transistor on the molecular scale
- Published (and peer reviewed) papers were suspected to contain duplicated and anomalous data
- Dismissed after an investigation found 24 cases of misconduct
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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

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

http://en.wikipedia.org/wiki/Research

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Higher Education Funding Council for England

Original investigation to gain knowledge and understanding

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