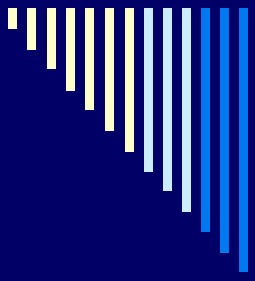
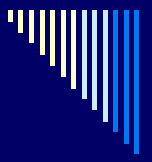


Computing Science Research

- **Kudang B. Seminar**



Computing Science is a misnoma.

- **Topics that are currently considered part of the discipline of computing science are technology rather than theory driven**
- **This creates problems if academic departments are to impose scientific criteria during the assessment of graduate students**
- It is, therefore, important that people ask themselves *`What is Research in Computing Science'* before starting on a higher degree

What is research?

- The systematic investigation into and study of materials, sources, etc, in order to establish facts and reach new conclusions
- An endeavour to discover new or collate old facts etc by the scientific study of a subject or by a course of critical investigation.

Dialectic of Research

- **Thesis**: This presents the original statement of an idea. However, very few research contributions can claim total originality. Most borrow ideas from previous work, even if that research has been conducted in another discipline.
- **Antithesis** :This presents an argument to challenge a previous thesis. Typically, this argument may draw upon new sources of evidence and is typically of progress within a field.
- **Synthesis** :This seeks to form a new argument from existing sources. Typically, a synthesis might resolve the apparent contradiction between a thesis and an antithesis.

Examples of Dialectic Research

- Debate over prototyping. For example, some authors have argued that prototypes provide a useful means of generating and evaluating new designs early in the development process (***thesis***), (Fuchs, 1992).
- Others have presented evidence against this hypothesis by suggesting that clients often choose features of the prototyping environment without considering possible alternatives (***antithesis***) (Hayes and Jones, 1989).
- A third group of researchers have, therefore, developed techniques that are intended to reduce bias towards features of prototyping environments (***synthesis***) (Gravell and Henderson, 1996).

Research in a field progresses through the application of methods to prove, refute and reassess arguments in this manner

Models of Argument

- Proof by demonstration
- Empiricism
- Mathematical proof
- Hermeneutics

Proof by Demonstration

- There are numerous examples of this approach being taken within the field of computer science. It is possible to argue that the problems of implementing multi-user operating systems were solved more through the implementation and growth of UNIX than through a more measured process of scientific inquiry.
- However, there are many reasons why this approach is an unsatisfactory model for research. The main objection is that it carries high risks. For example, the artefact may fail long before we learn anything about the conclusion that we are seeking to support. Indeed, it is often the case that this approach ignores the formation of any clear hypothesis or conclusion until after the artifact is built. This may lead the artifact to become more important to the researcher than the ideas that it is intended to establish.
- The proof by demonstration approach has much in common with current engineering practice. Iterative refinement can be used to move an implementation gradually towards some desired solution. The key problem here is that the iterative development of an artifact, in turn, requires a method or structure.

Empiricism

It has produced the most dominant research model since the seventeenth century. It can be summarised by the following stages:

- ***Hypothesis generation:*** ***identifies the ideas that are to be tested by the research***
- ***Method identification:*** ***identifies the techniques that will be used in order to establish the hypothesis. This is critical because it must be possible for one's peers to review and criticise the appropriateness of the methods that you have chosen. The ability to repeat an experiment is a key feature of strong empirical research.***
- ***Result compilation:*** ***presents and compiles the results that have been gathered from following the method. An important concept here is that of statistical significance; whether or not the observed results could be due to chance rather than an observable effect.***
- **Conclusion:** ***the conclusions are stated either as supporting the hypothesis or rejecting it. In the case that results do not support a hypothesis, it is important always to remember that this may be due to a weakness in the method. Conversely, successful results might be based upon incorrect assumptions. Hence, it is vital that all details of a method are made available to peer review.***

Mathematical Proof

- The central idea in this work is that mathematics can be used to set up a system of rules about valid and invalid inferences. These rules can then be applied to work out whether or not a conclusion is a valid inference given some initial statements about a program or some hardware.
- It is, however, possible to identify two different approaches to the use of formal proof as a research technique in computing science: (1) *argument of verification:* this attempts to establish that some good property will hold in a given system. (2) *the argument of refutation:* rather than attempting to prove the correctness of an argument, this approach attempts to refute it.
- The attractions of mathematical proof techniques are very strong. They provide a coherent framework for analysing research questions in computing science

Difficulties of Mathematical Proof

- incredible care needs to be made over the interpretation of results from mathematical proof.
- problem with formal reasoning is that their scope is limited. Interactive and time critical systems pose specially challenges for the application of mathematics
- relates to the cost of applying formal techniques. It takes a long time to acquire the necessary skills.
- there is inadequate discussion about the failures of formal methods. Errors in the application of mathematical reasoning can be seen as a source of shame rather than a learning opportunity for one's colleagues and peers.

Hermeneutics

- The distance between mathematical models and reality is, popularly, know as the formality gap. Hermeneutics provide an alternative that addresses this problem. Hermeneutic research methods have been pioneered within the field of sociology.
- Hermeneutic research, therefore, relies upon the interpretation of signs and observations in the working context rather than on explicity asking people about the performance of their systems
- Hermeneutics techniques urge researchers to enter into the workplace.

Conclusions

- Unfortunately the development of computing technology has not been matched by a similar development in academic research techniques.
- In the pursuit of technological goals, researchers have borrowed models of argument and discourse from disciplines as varied as philosophy, sociology and the natural sciences. This lack of any agreed research framework reflects the strength and vitality of computing science.
- A key aim of this paper is, however, to encourage people to think about the costs that have also been incurrend by the heterogenous nature of research in our discipline.
- I do not argue that we must develop a single research model for Computing Science. I do, however, argue that researchers must actively think about the strengths and weaknesses of the research tradition that they adopt.
- Too often, MSc and PhD theses slavishly follow empirical or formal proof techniques without questioning the suitability of those approaches.
- The tragedy is that unless we begin to recognise these failures then we will continue to borrow flawed research methods from other disciplines