Engineering Design Literature:

A View from Glasgow

Steven MacGregor

DMEM, University of Strathclyde, Glasgow

June 1, 2001

Contents

- Personal literature review
  - Study of distributed teams (CSCW & Knowledge management)
- Design community worldwide
  - Location/PI/Themes
- ED research evolution

Motivation

The field of engineering design is a complex one which overlaps with many other fields of study

+

Literature studies are typically done with insufficient rigor by the graduate community

=

A need, therefore, exists to study the literature from different perspectives and disciplines

PART 1
PERSONAL LITERATURE

Personal literature

KITE - Knowledge Integration and Transfer for Engineering design

The study of geographically distributed engineering design teams (in industry) and the role that design knowledge plays in their communication

Primary domains

KITE
LITrev

- **Computer Supported Co-operative Work (CSCW)**

*the study of how people work together using computer technology, specifically in **distributed** situations.*

Includes behavioural and technological issues

- **Knowledge management**

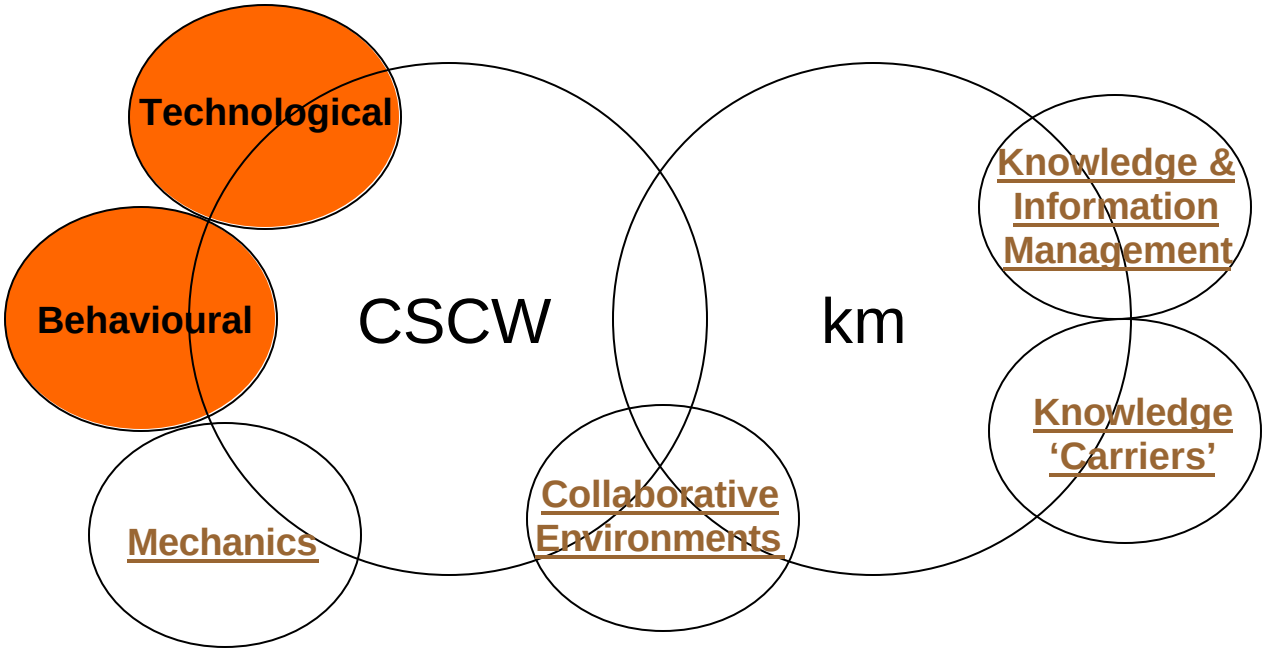
the capture and re-use of organisational knowledge

Recent 'phenomena' but lot not new – making knowledge visible, codifying etc

Knowledge = objects (management of information)

Knowledge = processes (management of people)

Model



A1a CSCW Mechanological

Investigates the technical aspects of CSCW. CSCW aims to be applied and focuses on frameworks and case studies within Computer Science but apply it in context along with practical and logistical issues.

A1b CSCW Behavioural

Investigates the primary behavioural aspects of CSCW such as discourse and trust. Much is based within the psychology domain.

CSCW Mechanics

KITE
LITrev

Systems/software for groups – GROUPWARE

Critical mass required for adoption of many systems

Often people who put in effort do not receive benefit

Cockburn and Jones, Dix

Design team members do most of work outside of formal meetings and through opportunistic interactions

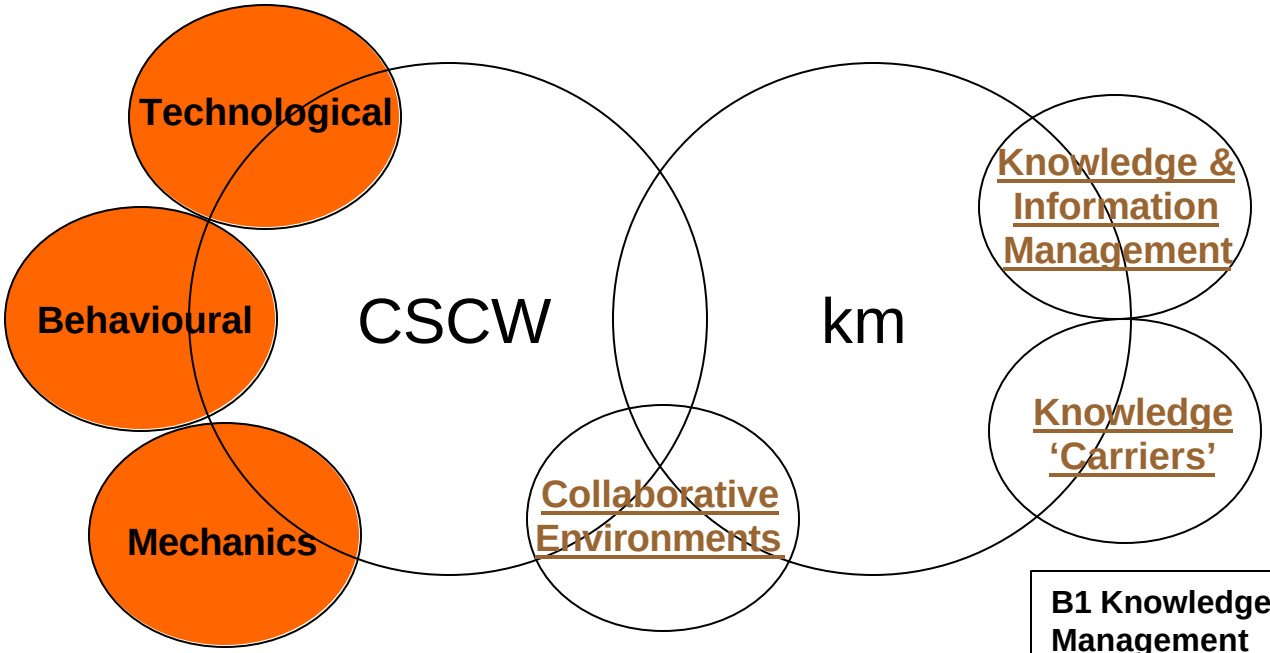
Frequency of interactions decrease as physical distance increases

Poltrock and Engelbeck, Kraut

Distributed work has to take account of the *taskwork* and the *teamwork* (the work of working together)

Gutwin and Greenberg

Model



B1 Knowledge & Information Management

A very broad viewpoint of K&I management is contained in this section, including different disciplines on an organisational level.

K and I management

KITE
LITrev

Four step process – Boynton

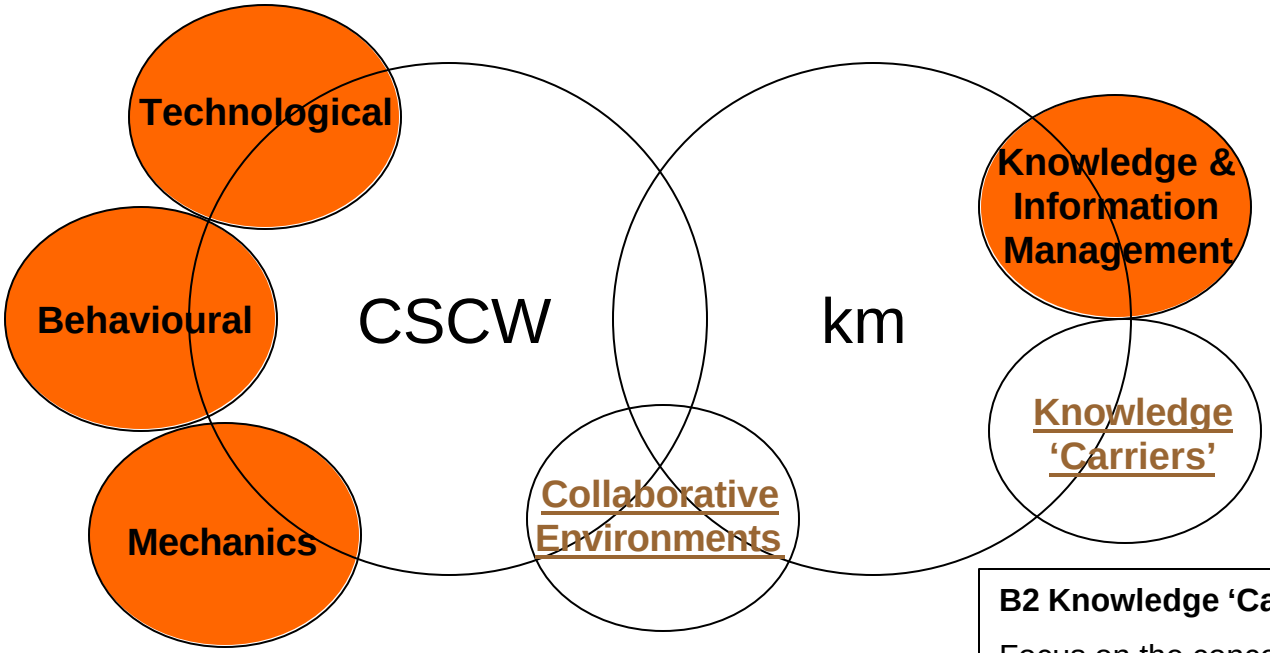
- Making knowledge visible
- Building knowledge intensity
- Developing a knowledge culture
- Building knowledge infrastructure

Knowledge management for the Internet age – Schwartz et al.

- ACQUIRE – Give (Gather, Inquire, Validate/Verify, Encode)
- ORGANISE – Parc (Profile, Associate, Rank, Classify)
- DISTRIBUTE – Aid (Awareness, Identification, Delivery)

Model

KITE
LITrev



B2 Knowledge 'Carriers'

Focus on the concept of knowledge and investigate ways of representing and manipulating it. Much of these papers are centred on Engineering Design and include aspects of AI, among others.

Knowledge ‘carriers’

KITE
LITrev

Distributed working can be an exchange of information and knowledge

MacGregor

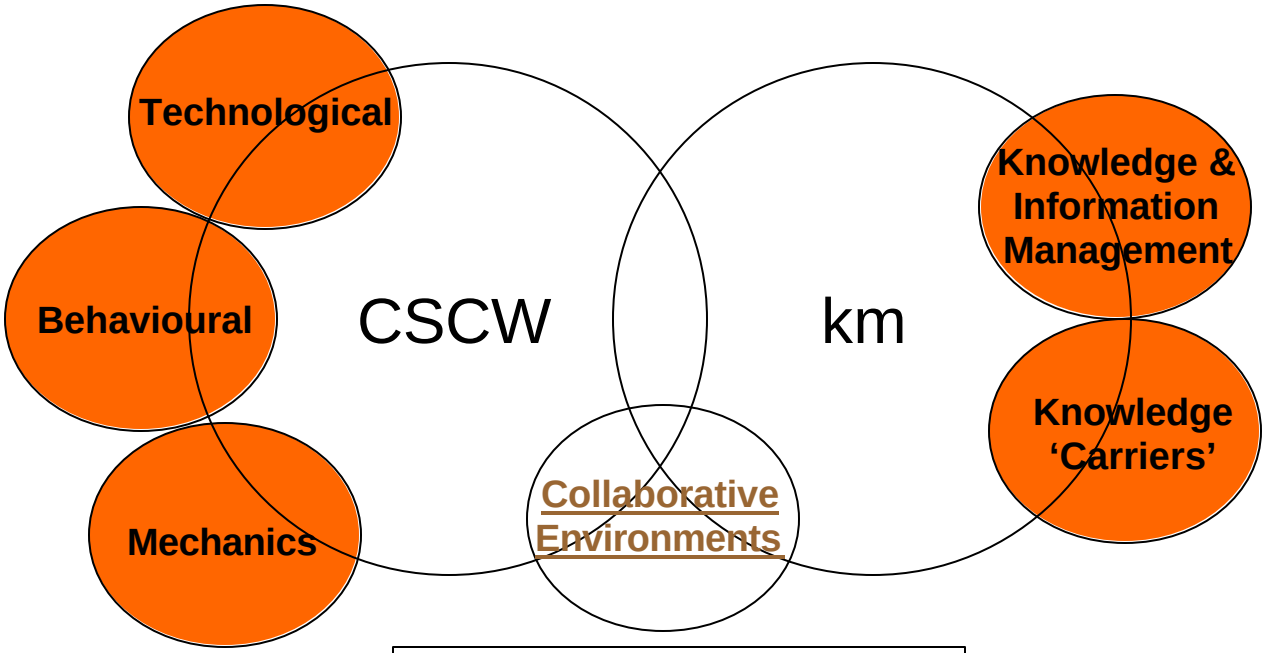
How do we **represent** this exchange?

Knowledge representation
Product Structuring
Design modelling
Design language
Andreaasen, Duffy

How do we **capture** this exchange?

Knowledge Based Systems (KBS)
Case Based Reasoning (CBR)
Neural networks
Object orientation
Product Data Management (PDM)

Model



AB1 Collaborative Environments

Investigate collaborative environments, particularly within engineering and design fields. Outputs may be concepts of a design studio etc and include both CSCW and knowledge aspects.

Collaborative environments

KITE
LITrev

Combine many **elements** which exist within the CSCW and knowledge fields

Commercial – MS NetMeeting, Lotus Notes

Research – Design studio concept popular
Education *(Maher)*
Industry *(Regli)*

Design repositories
Rationale capture
Ontologies

Open Hyperdocument System (OHS) Engelbart

END PART 1
DISCUSSION?

NEXT:
DESIGN COMMUNITIES

The Design Community

Few trained as designers, most come from other fields, usually Mechanical Engineering (own PDE course started in 1991)

Conferences

ICED - International Conference on Engineering Design (97, 99, **01**, 03)

ASME DETC (Design Engineering and Technical Conferences) Annually

Professional bodies

No real standard - UK - IMechE/IEE - IED very small

US - Design Division of ASME?

ICED currently attempting to start new professional society for designers

The Design Community

Journals

Research in Engineering Design

Design Studies

Journal of Engineering Design

Design Management

Artificial Intelligence in Engineering

Artificial Intelligence in Engineering Design, Analysis and Manufacture

CAD

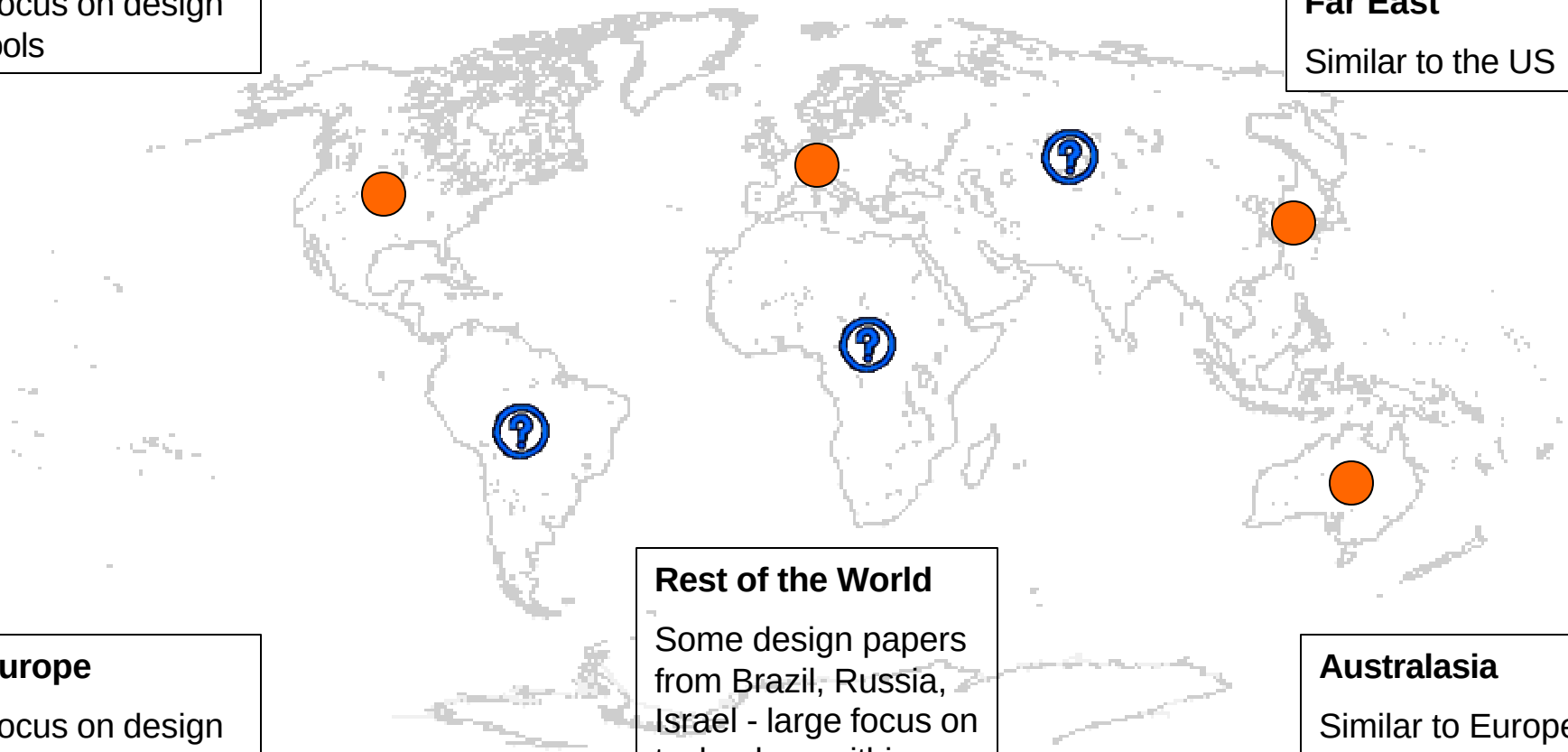
The Design Community

US &Canada

Focus on design tools

Far East

Similar to the US



Rest of the World

Some design papers from Brazil, Russia, Israel - large focus on technology within India

Europe

Focus on design theory and methodology

Australasia

Similar to Europe

The Design Community

US & Canada

Stanford	Leifer - *design methodology, collaborative working*
CMU	Finger - *team working, knowledge modelling*
	Subrahmanian - *collaborative working, information sharing*
MIT	Malone - *co-ordination, design history*
	Nam Suh - *design axioms*
Texas	Woods - *functional modelling*

NRC Canada, Calgary

The Design Community

United Kingdom

Strathclyde	Duffy - *design co-ordination, situatedness*
Cambridge	Wallace - *research methodology, knowledge management*
Bath	Culley - *information sharing*
Leeds	De Pennington - *design theory and methodology*

EPSRC - main Government body

The Design Community

Europe

Denmark	Andreaasen - *design methodology, product development*
Berlin	Blessing - *research methodology, knowledge management*
Bordeaux	Girod - *design management*
Spain	Smithers - *design theory, knowledge modelling*
Turin	Cantamessa - *design performance and management*

Munich, Darmstadt, Magdeburg, Chalmers (Sweden), Delft (Netherlands)

The Design Community

Australasia and Far East

Sydney	Gero - design theory, situatedness
	Maher - design studios
Tokyo	Tomiyama - knowledge modelling and design tools

END PART 2
DISCUSSION?

NEXT:
DESIGN RESEARCH EVOLUTION

Design Research Evolution

Design re-use documented in 1800's

First 'Design Spiral' 1954

'Birth' of design research - creation of first design models - Asimo

Design methods and relation to design process - BS, R&W, Morph etc.

JC Jones, Design Methods - Seeds of Human Futures, 1970

Adoption of Japanese methods and paradigm shift to CE/SE - study of *Taguchi, TQM, QFD*

US introduction early 80's, UK late 80's

Examining the design process - creation of prescriptive and descriptive models - *Pugh, French, Pahl and Beitz*

Pre 1960

1960's

Small design groups - not understood in wider community

1970's

Big focus on manufacturing and quantity - *how many?*

1980's

But what about quality? Design starting to be understood - not just a burden

Design Research Evolution

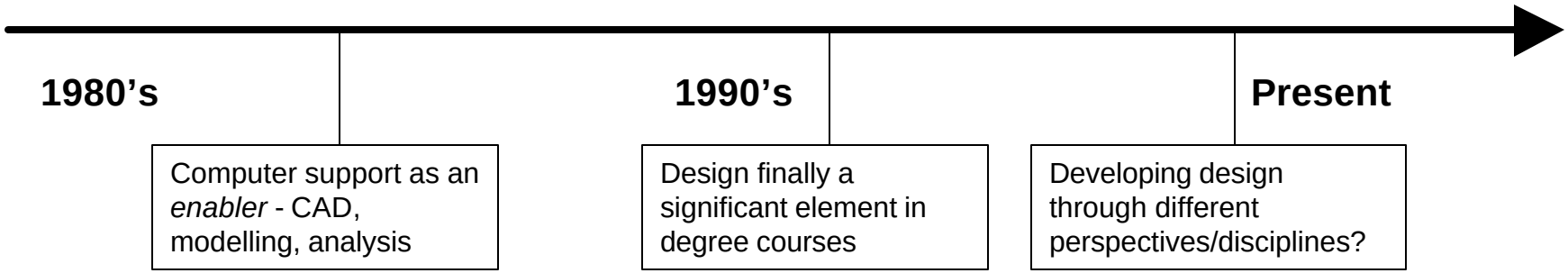
Further progression of methods and process models - period of consolidation through 80's and 90's

Technology focus - CSCW, mobile design, knowledge management, another shift imminent to that of CE/SE?

Aspects of performance, teaching and learning in design

Concept of Knowledge engineering, driven by new technology, substantial growth of AI, expert systems etc

Design issues related to new technology - Design Co-ordination, Situatedness in Design



Design Research Evolution

Appropriate design statements/(mantras?)

Understanding design, product and process

Observe, improve, teach

Bringing design to the larger community - science and engineering

An understanding of design and the design process can be applied on a generic level and within many fields

Design Research Evolution

"Life (design), like surfing, requires 'catching the wave' at a precise moment"
Leifer

What's the next wave?

Continuing need for understanding

but, it's a moving target

Increasing size of design community to aid in 'quest'

but, are we teaching it correctly?

END PRESENTATION
DISCUSSION?

NEXT:
SOFTBALL GAME

Acknowledgements
Zuchao Wu, Alex Duffy,
Avril Thomson, Bill Ion

Next two presentations:

Wednesday, June 20th

Friday, July 27th

macgregor@cdr.stanford.edu

www-cdr.stanford.edu/~macgregor