

COMP3530/6353

Systems Engineering for Software Engineers – 2017

Connecting what we have covered so far

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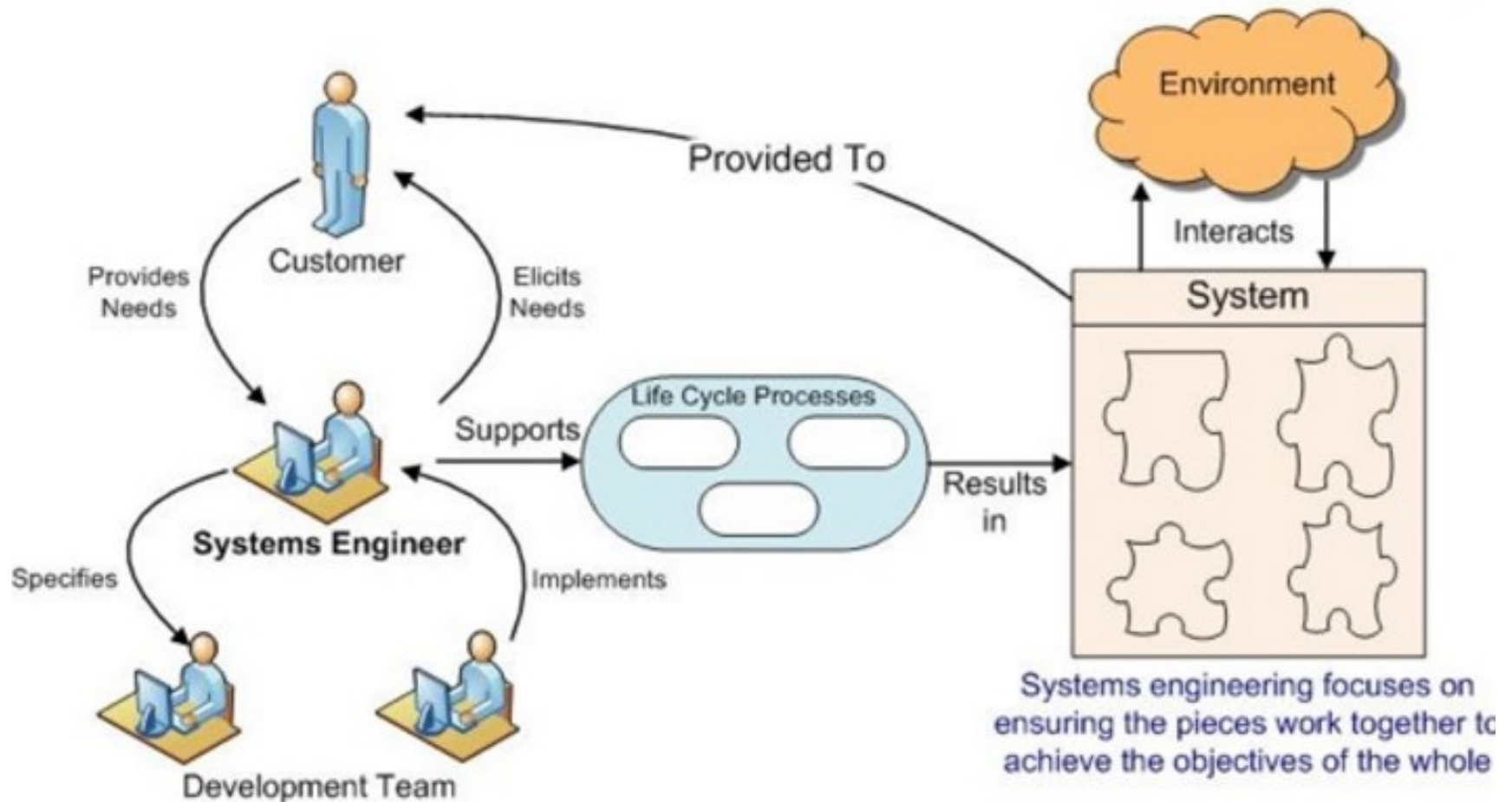
Content based predominantly on lecture slides produced by Shayne Flint in 2016
Flint, S. (2016). *COMP3530/6353 Systems Engineering for Software Engineers Connecting what we have covered so far*.

Topics covered so far

- Systems Engineering
- Systems Thinking (dealing with complexity)
- Design Thinking
- Environmental Concerns

Systems Engineering

What is it?



Key ideas – System Fundamentals

A set of elements in interaction

- **Elements** can be *natural, social, abstract* or *technical*
- **Interaction** may involve *influence, flows of materials, flows of information*

Bertalanffy, L., von. 1968. General System Theory: Foundations, Development, Applications, rev. ed. New York, NY, USA: Braziller.

Key ideas – System Fundamentals

System Environment

“The surroundings (natural or man-made) in which the system-of-interest is utilized and supported; or in which the system is being developed, produced or retired.”

INCOSE Systems Engineering Handbook, version 3.2.
San Diego, CA, USA:
International Council on Systems Engineering (INCOSE),
INCOSE-TP-2003-002-03.2.)

Key ideas – System Fundamentals

Complexity

“A measure of how difficult it is to understand how a system will behave or to predict the consequences of change it.”

(Sheard, S.A. and A. Mostashari. 2009.
"Principles of Complex Systems for Systems Engineering".
Systems Engineering, 12(4): 295-311.)

Key ideas – System Fundamentals

Emergence

“The principle that whole entities exhibit properties which are meaningful only when attributed to the whole, not to its parts.”

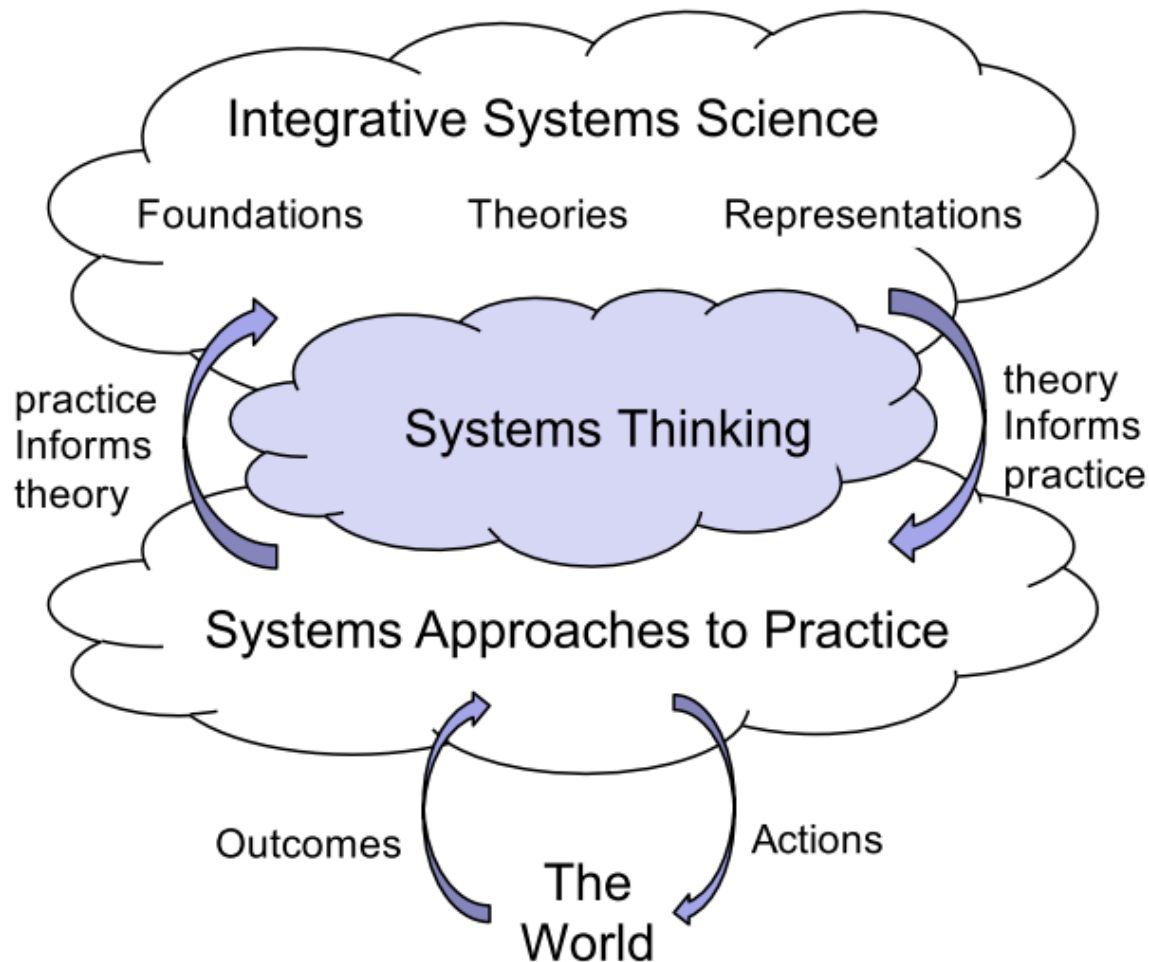
(Checkland, P. B. 1999.
Systems Thinking, Systems Practice.
Chichester, UK: John Wiley & Sons Ltd.)

How is 'Software Development'

connected to

'Systems' and 'System Environment'?

Key ideas – Systems Praxis Framework



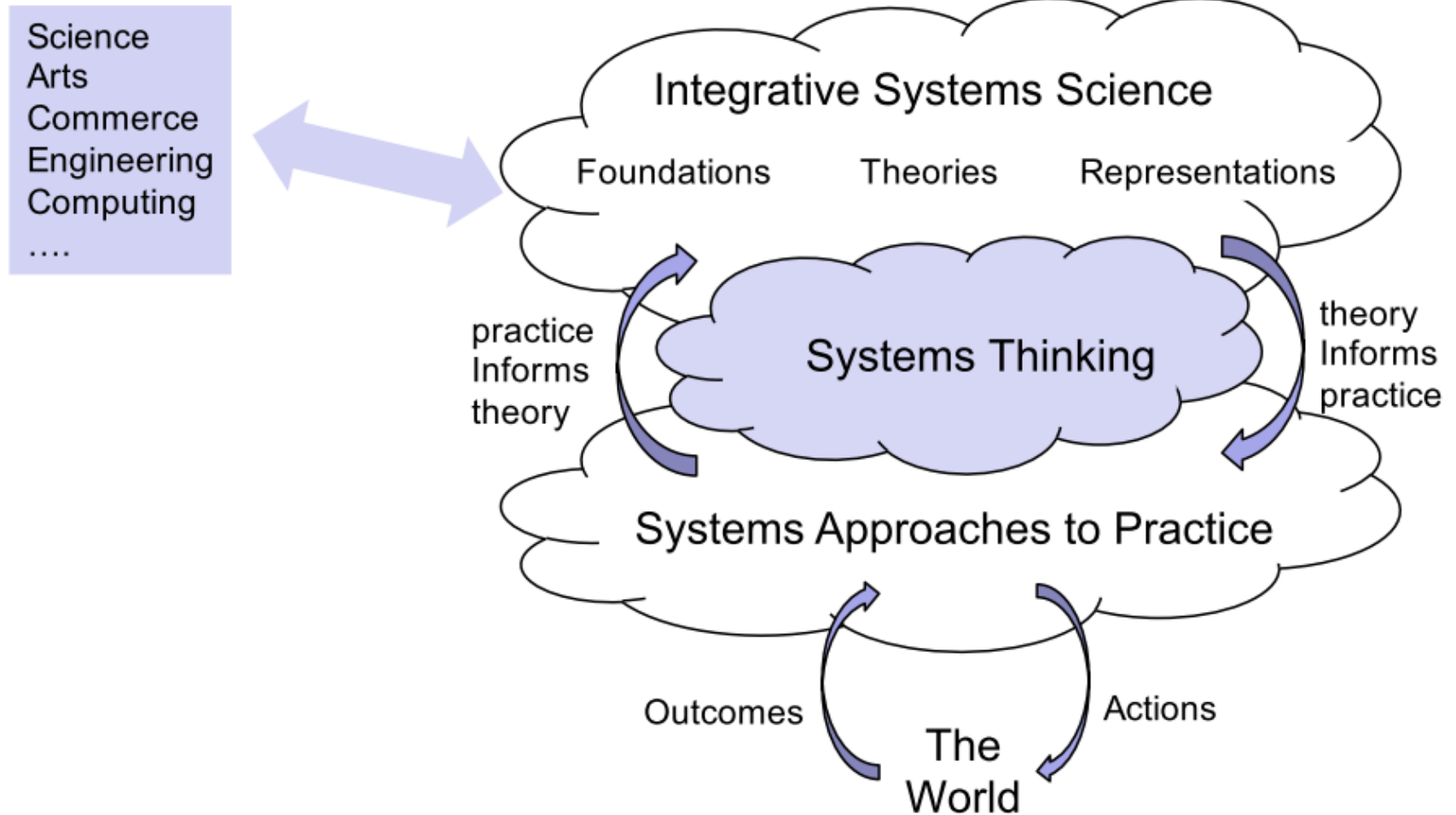
Making connections

How are the ‘Disciplines’

connected to

‘Systems Science’?

Key ideas – Systems Praxis Framework



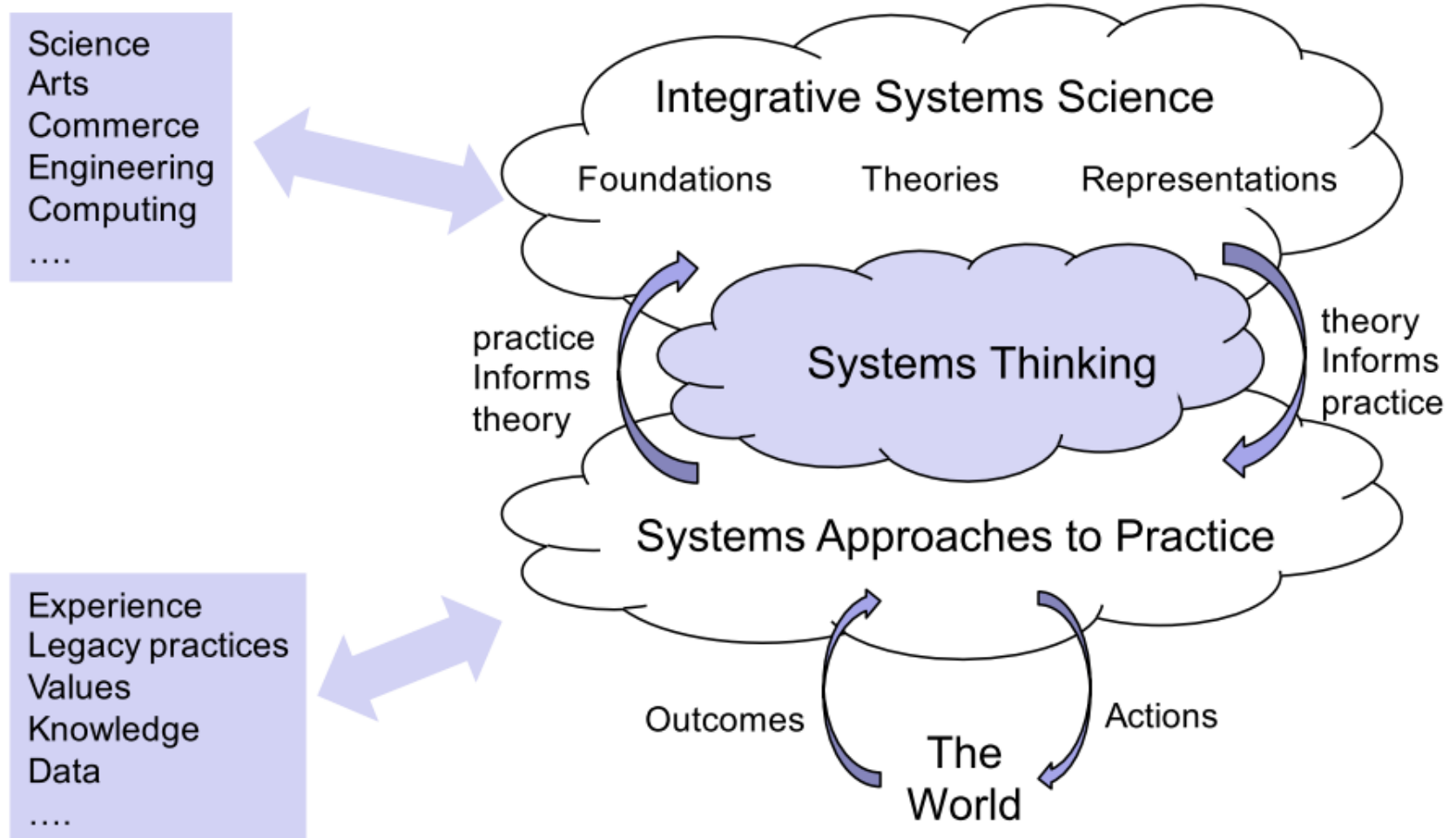
Making connections

How is 'Experience'

connected to

'Systems Practice'?

Key ideas – Systems Praxis Framework



Key ideas – ‘Problems’ vs ‘Problem Situations’

- **Problems**
 - Can be defined and solved
- **Problem Situations**
 - Are difficult to define
 - Different people perceive different issues
 - Complex ‘systems’ of ‘problems’ and ‘perceptions’
 - Russel Ackoff calls them ‘messes’ others refer to them as ‘wicked problems’
 - Cannot be solved
 - Can only be improved (from a given set of perspectives) through interventions

Making connections

How are different ‘Disciplines’

connected to

‘Problems’ and ‘Problem Situations’?

Making connections

How is 'Software Development'

connected to

'Problems' and 'Problem Situations'?

Systems Thinking

Key ideas – Systems vs Analytical thinking



Key ideas – Systems vs Analytical thinking



Key ideas – Systems vs Analytical thinking

Systems Thinking answers these questions by exploring the ***role*** the car plays within it's environment

Making connections

How is 'Software Development'

connected to

'Systems Thinking'?

Key ideas – Separation of Concerns

Multi-Dimensional

- Structure
- Discipline or specialisation
- Life-cycle phases and processes
- Versions
- Decomposition
- Abstraction

Focus attention on some aspect of the problem while remaining aware of other aspects

Making connections

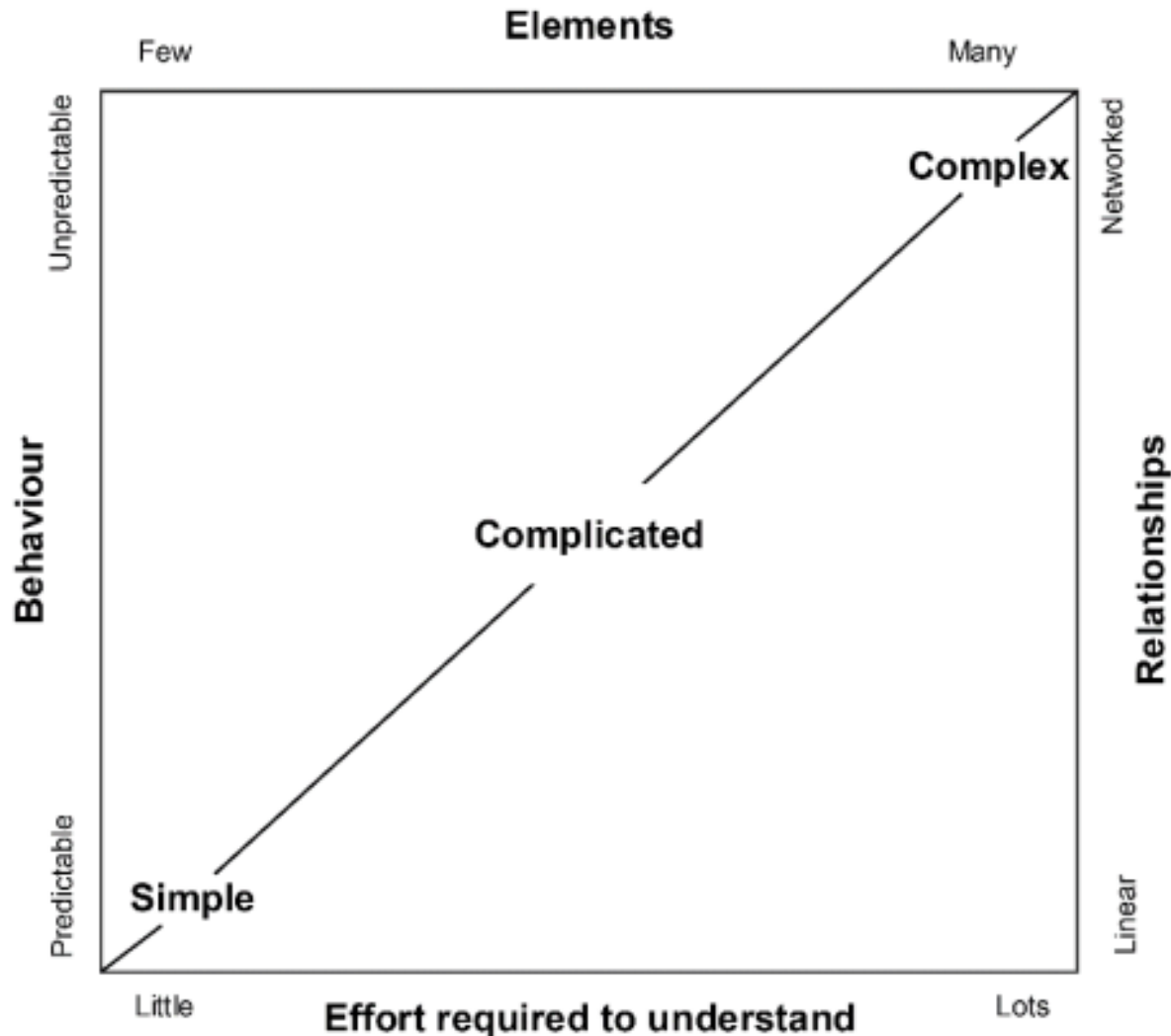
How is 'Separation of Concerns'

connected to

'Systems' versus 'Analytical' thinking?

System Complexity

Key ideas – Complicated versus Complex



Key ideas – Complicated vs Complex

Complicated

- Many variables & different combinations
 - e.g. Mercedes Benz trucks – 2,400 variants, 1000 suppliers
- Humans deal well with this

Complex

- Dynamic
- Interventions have multiple outcomes
- Humans are not good at dealing with this

Key ideas – Feedback Systems

- Composed of separate parts that **interact** to affect each other's behaviour over time
- You **cannot understand the behaviour** of such a system **by studying** only the **behaviour of the parts taken separately**
- **Feedback** makes a system **dynamically complex** and **causes unexpected outcomes** that are **almost always unwanted**

Key ideas – The Complexity Dilemma

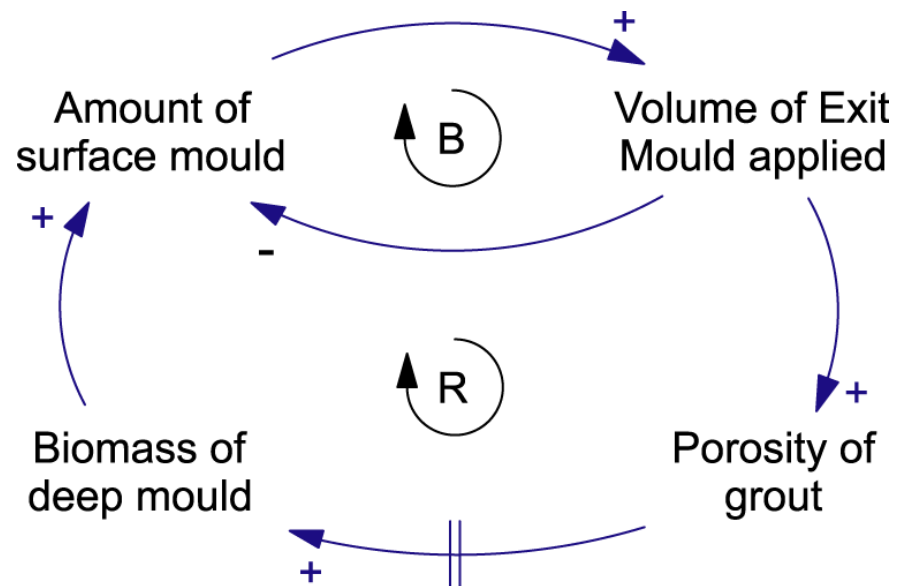
What is the dilemma?

- Overwhelmed by complexity when studying as a whole
- Cannot be understood as a whole or as a set of disconnected parts

Key ideas – The Complexity Dilemma

Escaping the dilemma?

- Look for common behaviour across domains
- System archetypes – e.g. ‘Fixes that Fail’



Making connections

How is 'Agile Development'

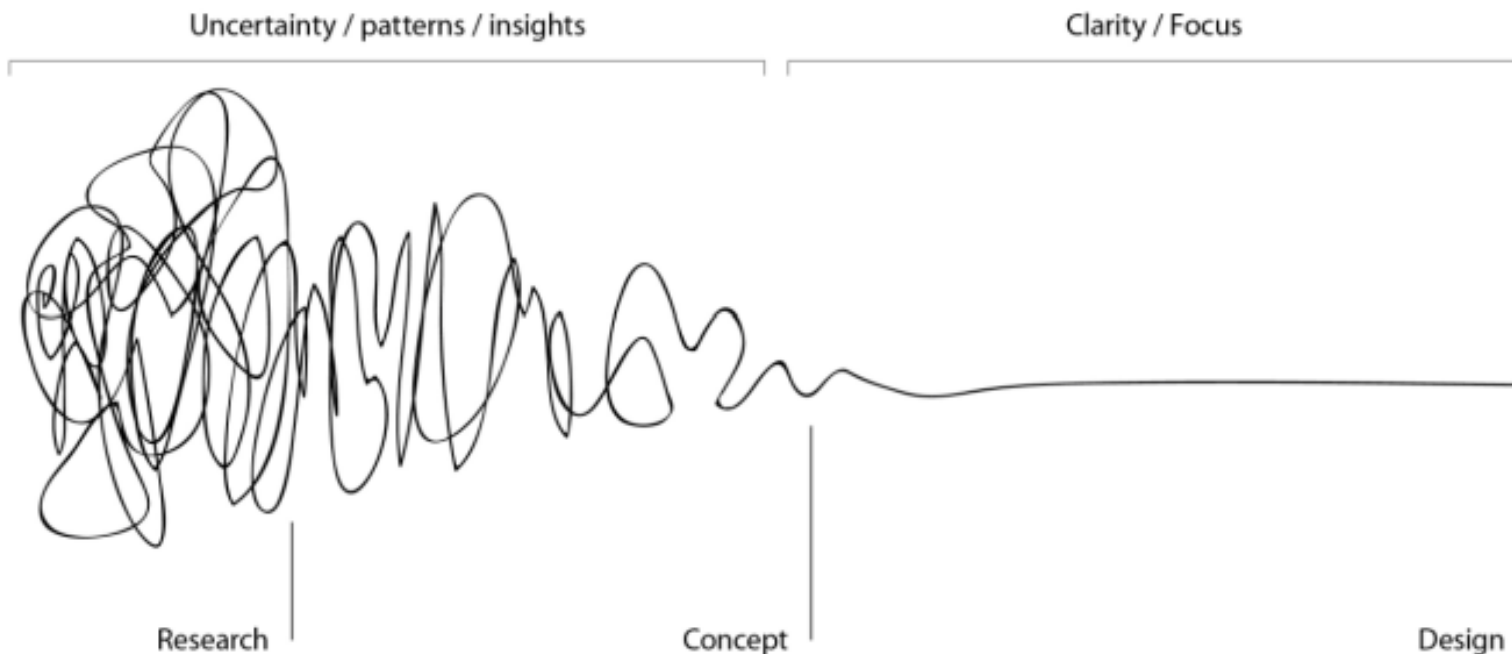
connected to

'Complicated' versus 'Dynamic Complexity'?

Design Thinking

Key ideas – The Design Squiggle

What is this and how does it relate to software development?



Key ideas – Design Thinking

What is Design Thinking?

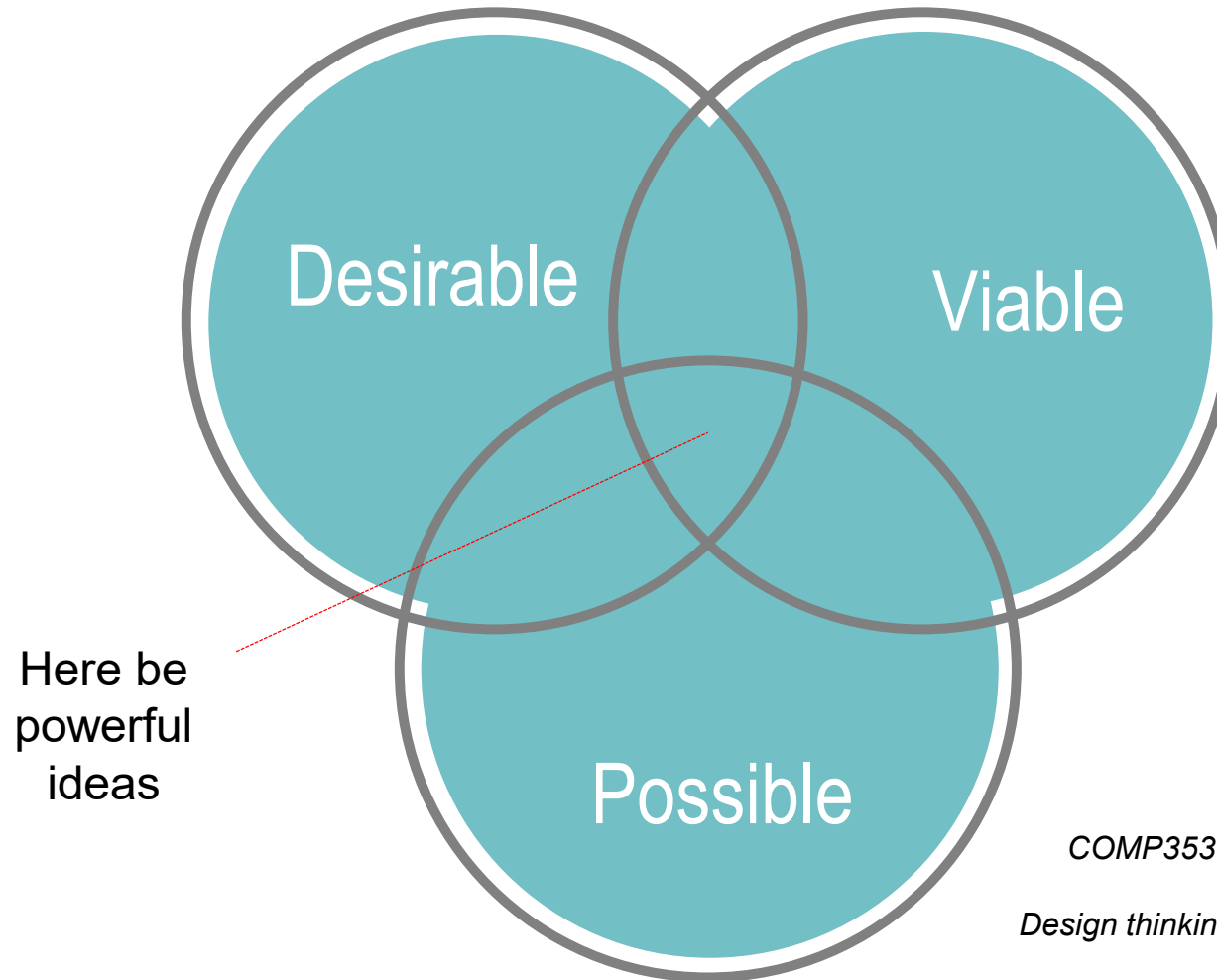
- A way of looking at the world
- An approach to tackling the unknown
- An exploration – without making assumptions about the challenge or the solution
 - Prototypes, experiments, fails, learns, iterates

Key ideas – Design Thinking

Five key elements

- Learn from people
- Find patterns
- Design principles
- Make tangible
- Iterate relentlessly

Key ideas – Design Thinking



Mellor, S. (2017).
*COMP3530/6353 Systems Engineering
for Software Engineers*
Design thinking and human-centred design
ThinkPlace.

Making connections

How is 'Design Thinking'

connected to

'Dynamic' complexity and 'System Dynamics'?

Making connections

How is 'Design Thinking'

connected to

'Software Development'?

Sustainability

Key ideas – Sustainable Development

Development that meets the needs of the present, without compromising the ability of future generations to meet their own needs.

WCED, 1987. Our Common Future. OUP

Key ideas – Sustainable Development



Making connections

How is 'Sustainable Development'

connected to

'Dynamic Complexity'?

Key ideas – Sustainable Development

What techniques could we use to engage in sustainable development?

Emergent Themes

Emergent themes across topics

- Context
- People
- Complexity
- *Intervention* rather than *solution*

Emergent themes across topics

Software Development is

- A dynamically complex activity
- Operating within a dynamically complex environment
- Aiming to create an effective intervention in a complex problem situation

Questions?

Don't forget –

Learning Portfolio due at the end of this
week.

Mid-Semester class survey