THE UNIVERSITY OF WESTERN AUSTRALIA

Achieving International Excellence

Engineering value creation
(Why engineer?)

iCEER 2016, Parramatta, Sydney

James Trevelyan,
Close Comfort Pty Ltd
School of Mechanical & Chemical Engineering
http://jamesptrevelyan.com/

Outline

- Engineering performance needs improving
- What do engineers do? What do they avoid?
- Engineering value creation
- Education implications

Issue #1:

Success rate for projects
(Success = financial return > 50% forecast @ FID)

- USD 100 million – 1 billion

- Over USD 1 billion

Merrow, E. W. (2011). Industrial Megaprojects: Concepts, Strategies, and Practices for Success. New Jersey, John Wiley & Sons.

Issue #2:

Safe Drinking Water Supplies

www.closecomfort.com/water/

USD 35-50/tonne

45% children stunted due to faecal contamination

Asianet Pakistan / Shutterstock

USD 70-130/tonne

Hyderabad, India

USD 3/tonne

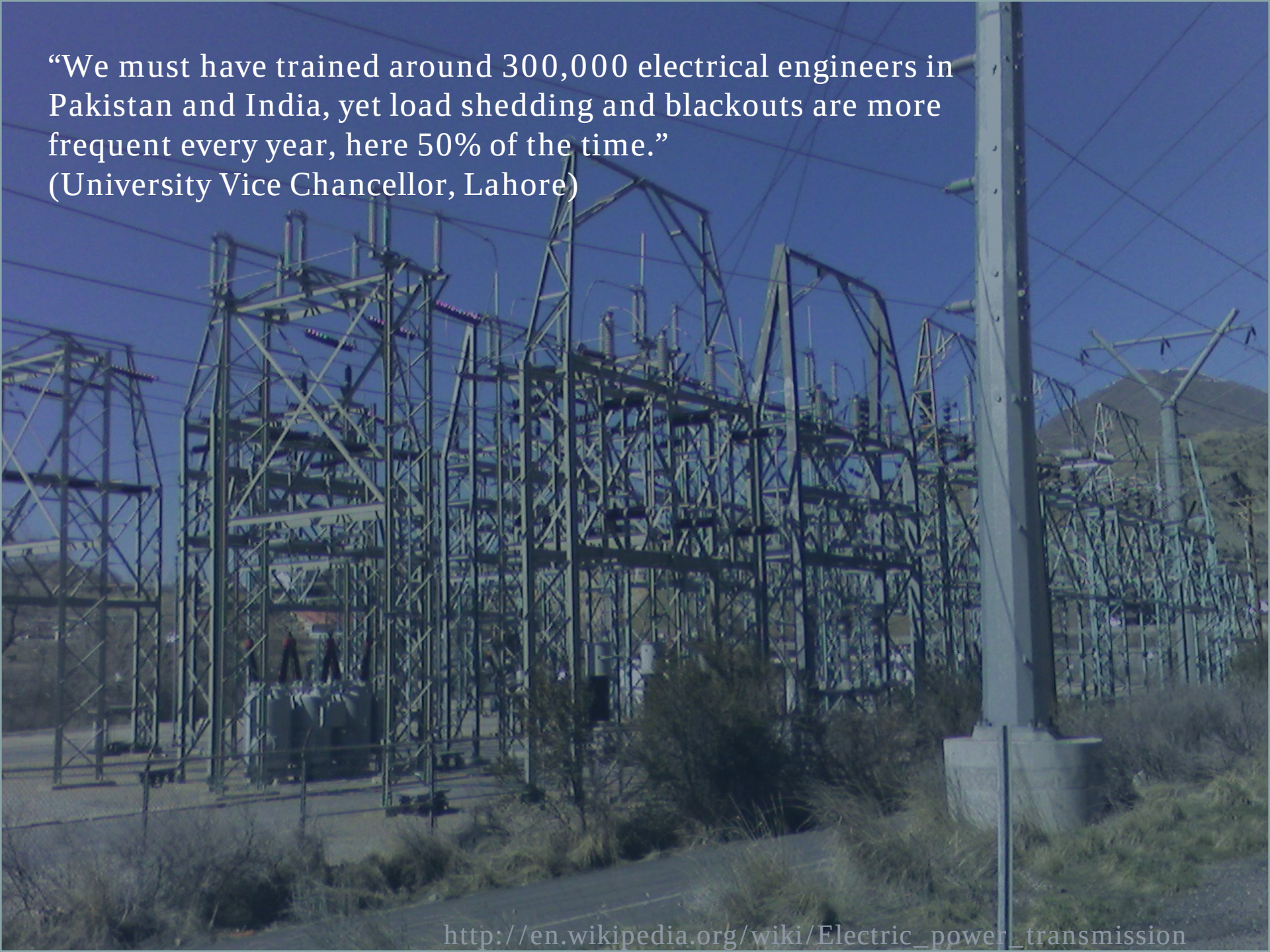
(Perth cost,
including connection, 2016)

Issue #3:

Energy Supplies

Load shedding (intermittent power) in many countries doubles or triples the cost of electric energy.

- Generators or batteries
- Equipment damage
- Process discontinuities



"We must have trained around 300,000 electrical engineers in Pakistan and India, yet load shedding and blackouts are more frequent every year, here 50% of the time."
(University Vice Chancellor, Lahore)

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

Issue #4:

High cost of emission reductions

Issue #5:

Pollution – China, India, Pakistan
Indonesia

Issue #6:

Productivity static or declining, persistent
low-income / high income gap

Energy efficiency options should save money.....

- engineers' arguments are ineffective

Saving up to

80%

on your air conditioner energy expenses

CloseComfort
PERSONAL AIR-CONDITIONING
The Smarter Way to Stay Cool

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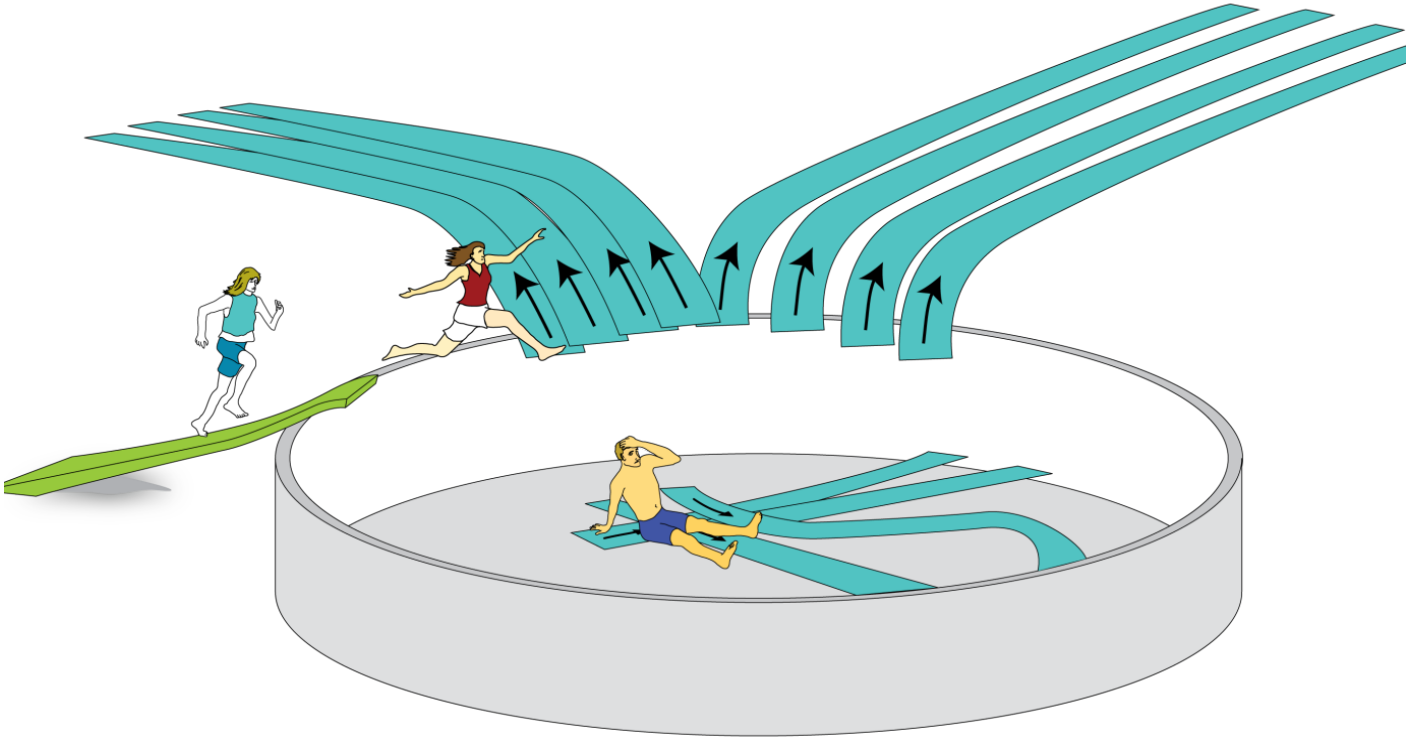
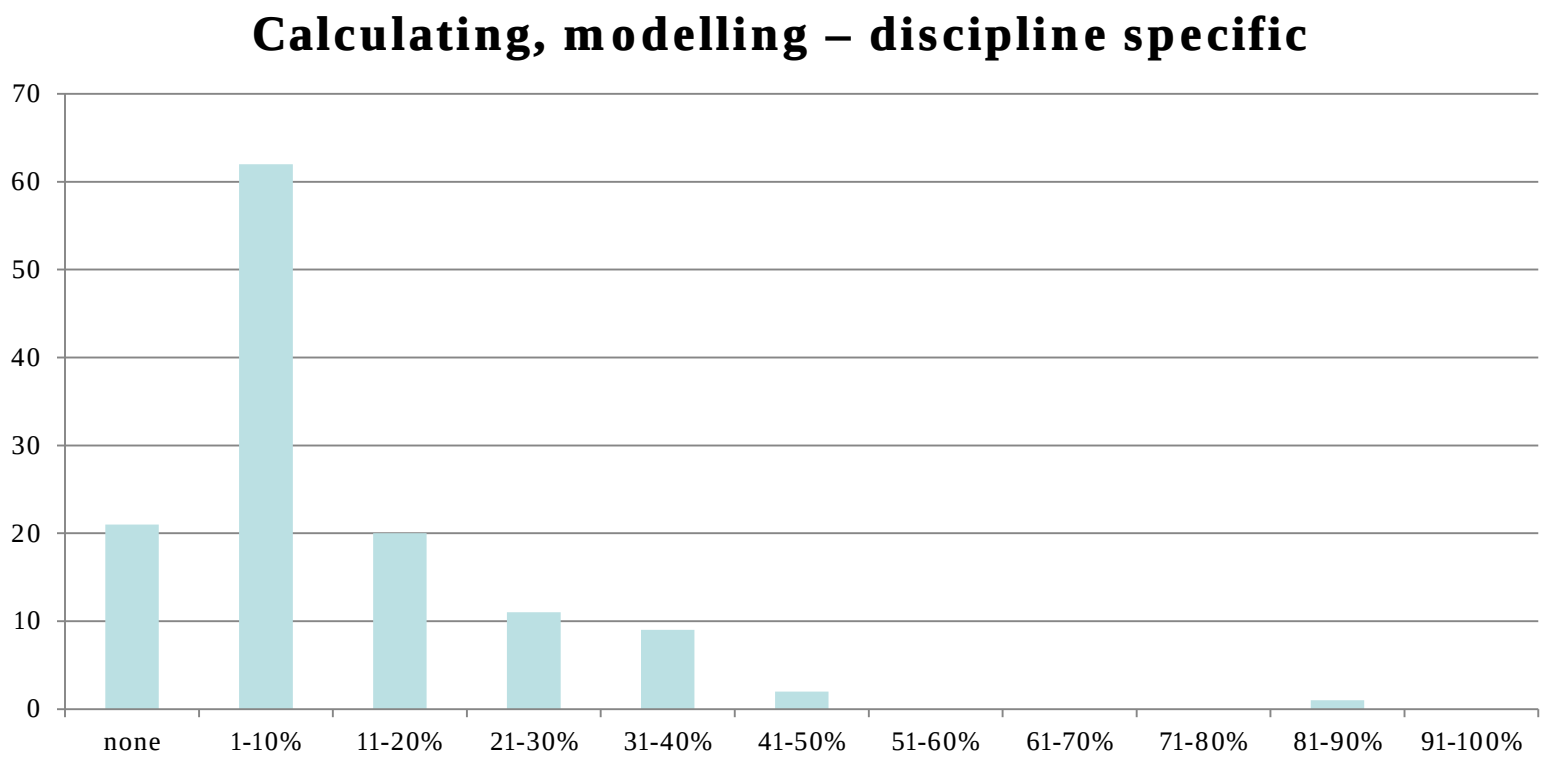
Theory-based education shapes a discipline

Engineering students at university learn to write mathematical solutions for narrowly defined technical analytical problem in examinations.



What do engineering graduates do in their first job?



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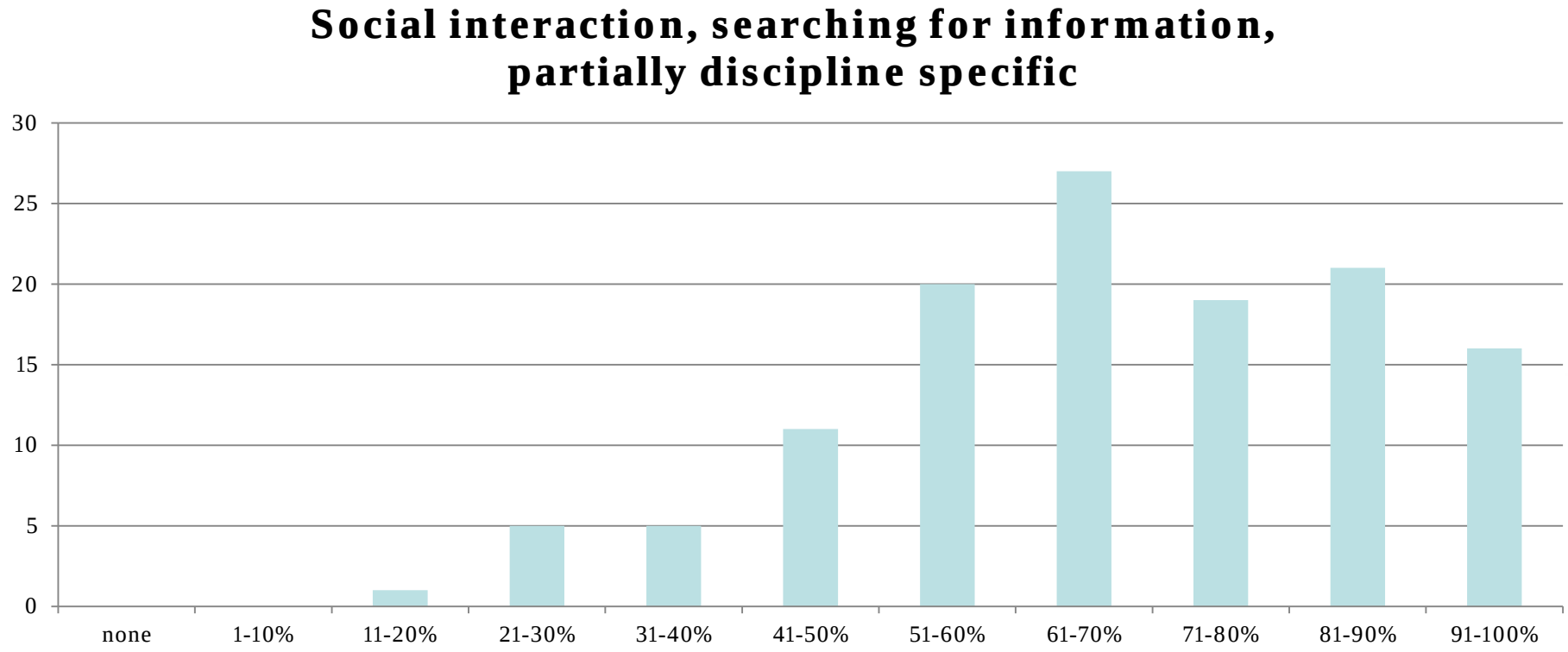
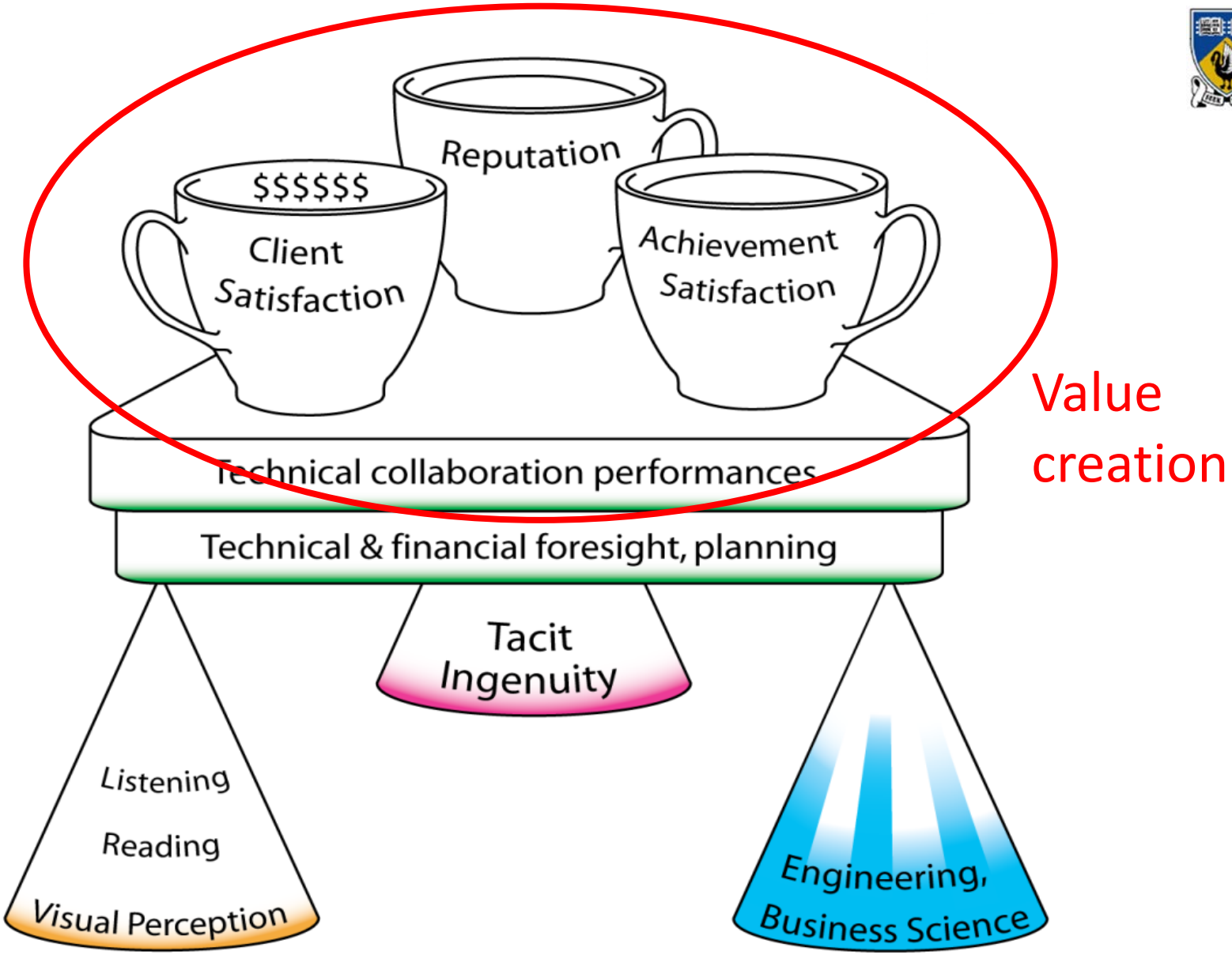
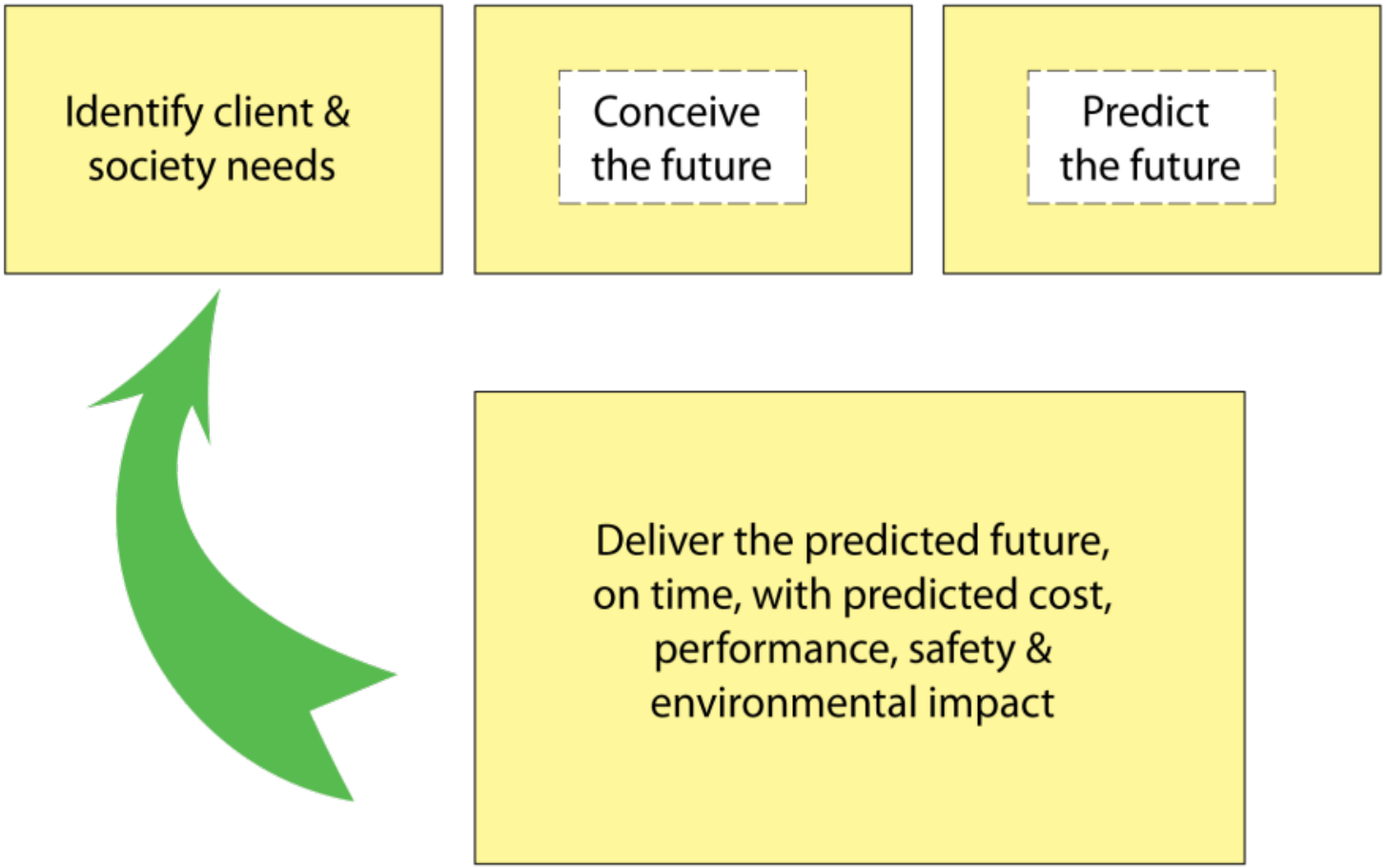


While it may see non-technical, analysis shows the social interactions are largely about technical issues

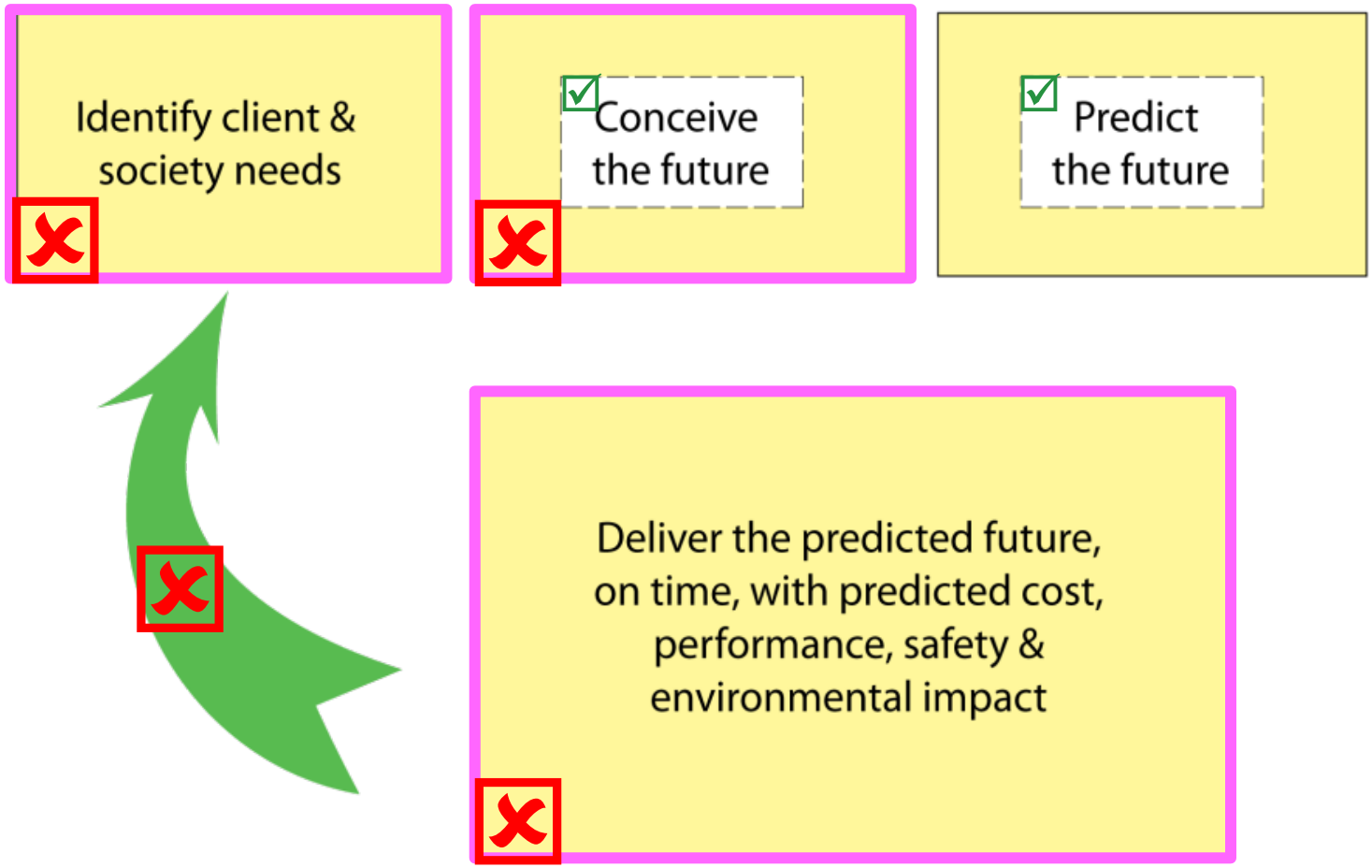


Trevelyan, James P. (2014) The Making of an Expert Engineer, Taylor & Francis

A view of engineering practice



A view of engineering practice



What do we teach?

- Engineering science, 2-20% of practice

What do we not teach?

- Technical collaboration 80 - 98% of practice

What is seen as “real engineering”?

- Engineering science, 2-20% of practice

What is not seen as “real engineering”?

- Technical collaboration 80 - 98% of practice

What do engineers do well?

- Engineering science, 2-20% of practice

Where is there potential to improve?

- Technical collaboration 80 - 98% of practice

Employers are frustrated

"Whenever I find an engineer in my organization, I sack them on the spot"

(CEO of one of Australia's largest mining companies)

"Engineers frustrate me immensely: they just don't understand the business imperatives of this organization"

(CEO of a global mining company)

Value perceptions

Engineers

- Rarely if ever mention value creation
- Efficiency savings
- Precision, eliminate uncertainties
- Risk management
- Schedule and budget constraints externally imposed

Investors

- Starting point for decisions
- Will it work?
- Will it be ready on time and within budget?
- Will it kill or injure someone?
- Will it be delayed or closed because of environmental concerns?

What do most engineers avoid?

- Design checking
- Maintenance
- Specifications
- Procurement
- Meetings
- Follow-up
- Phone calls
- Face to face encounters (email/phone/Skype preferred)

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Value?

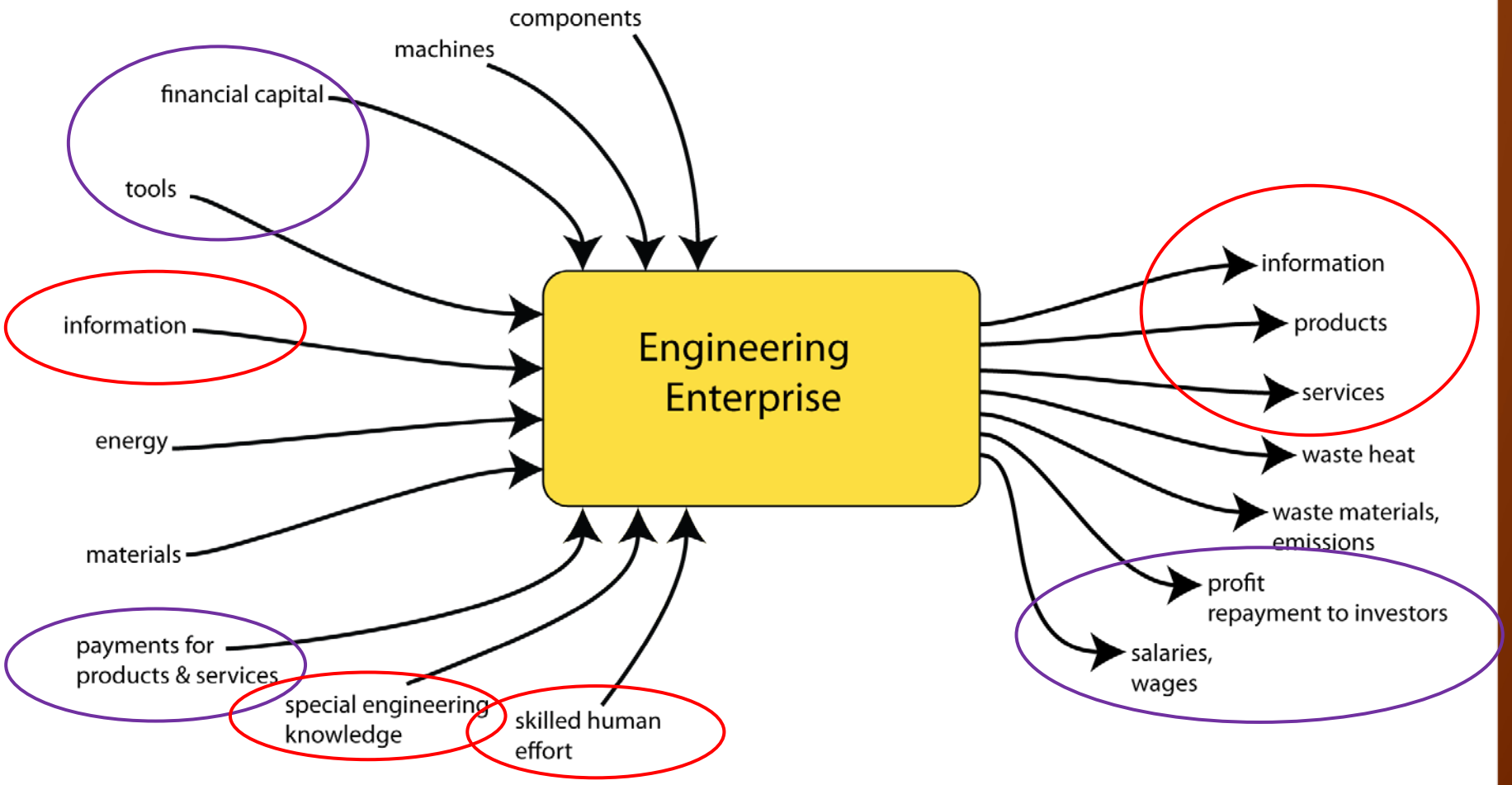
- X=2.7266754?
- $?
- Exchange-value
- Artefact acquisition, or entitlement to service
- Use-value (actual, or anticipation of)
- Subjective experience, perception
- Unique to each person
- Depends on circumstances, time
- Co-created by provider and user

Ng, I. C. L., Parry, G., Smith, L. A., & Maull, R. S. (2010). Value co-creation in Complex Engineering Service Systems: Conceptual Foundations *Forum Markets and Marketing: Extending the Service Dominant Logic (pp. 19): University of Exeter Business School Discussion Papers in Management 10/04.*

Value?

gadgetadda.com, March 2016

The firm (or enterprise)



Ch5, The Making of an Expert Engineer

Porter's Value System

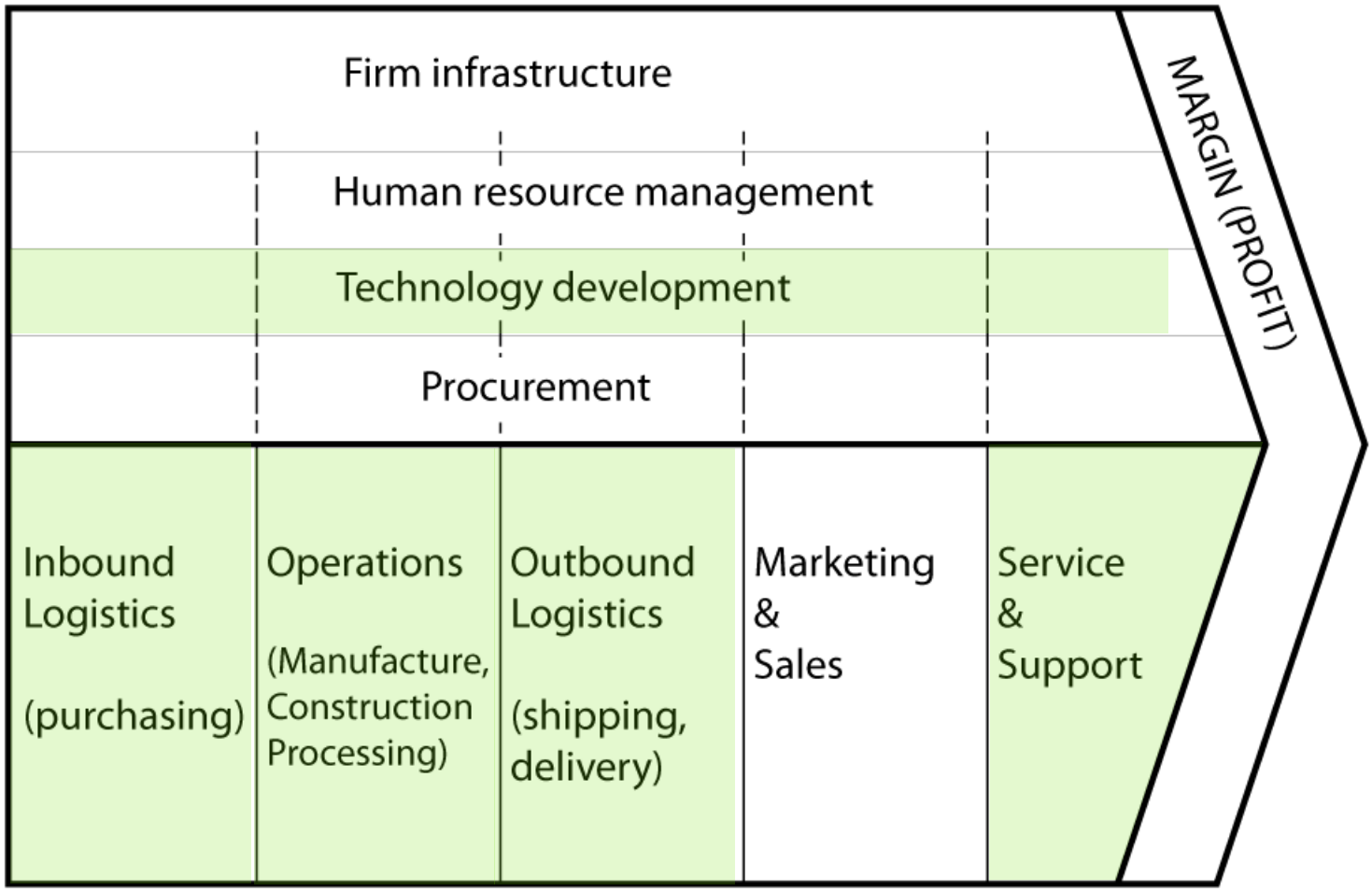
- Each firm (or enterprise) operates with a "value system"
- Product exchange-value > sum of input exchange-values (profit)

Porter, M. E. (1985). *Competitive advantage: creating and sustaining superior performance. New York: Free Press.*

Porter's Value System

- Each firm (or enterprise) operates with a "value system"
- Product exchange-value > sum of input exchange-values (profit)
- Firms *differentiate* their products to
  - Reduce firm's input costs
  - Increase buyer value
  - Increase product exchange-value (margin)

How do engineers contribute value?



Innovation

- Implied link between engineering value creation and innovation (Schumpeter 1911:1934)
- What happens if there is no innovation?
- Little or no value created?

Schumpeter, J. (1911:1934). *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle. Translated from the 1911 original German, Theorie der wirtschaftlichen Entwicklung. Cambridge, Massachussetts, USA: Harvard University Press.*

But, what actually creates value?

Example

- Compliance engineer

Example

Structural engineer who approves designs for floor slabs and structural beams in residential buildings

- Does no design work
- Checks designs created by other people
- Increases cost, time
- How does the engineer create value?

Engineering Practice

Identify client & society needs

Conceive the future

Predict the future

Deliver the predicted future, on time, with predicted cost, performance, safety & environmental impact

Engineering Value Creation

1. Reduce human effort, material, energy
2. Reduce uncertainty, reduce design margins
3. Design for improved buyer and end-user experience – product differentiation (Porter)
4. Innovation – transformation of ideas into innovative products and services (Zhang)
5. Shared value creation – health, safety, environment, education, capacity building (Kramer, Porter)
6. Providing commercial and technical predictions to build confidence for investment (Trevelyan)
7. Organisation, coordination for reliable delivery with sufficient performance to justify repeat business (Trevelyan)

Zhang, Y., & Gregory, M. (2011). Managing global network operations along the engineering value chain. *International Journal of Operations and Production Management, 31(7), 736-764.*

Engineering Value Protection

8. Defence equipment and services (Zhang)
9. Shared value creation – health, safety, environment, education, capacity building (Kramer, Porter)
10. Maintenance, sustainment, engineering asset management (Trevelyan)

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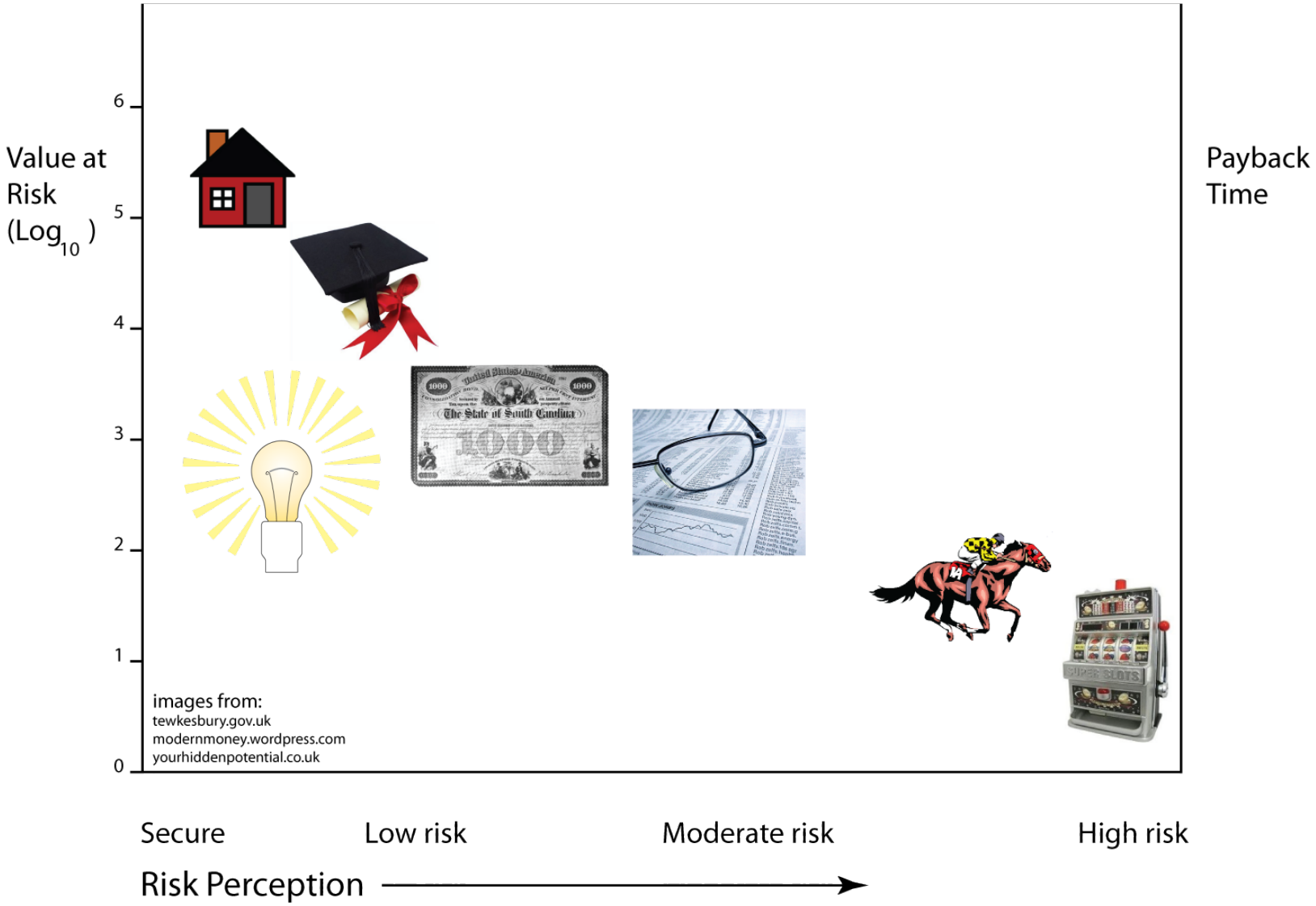
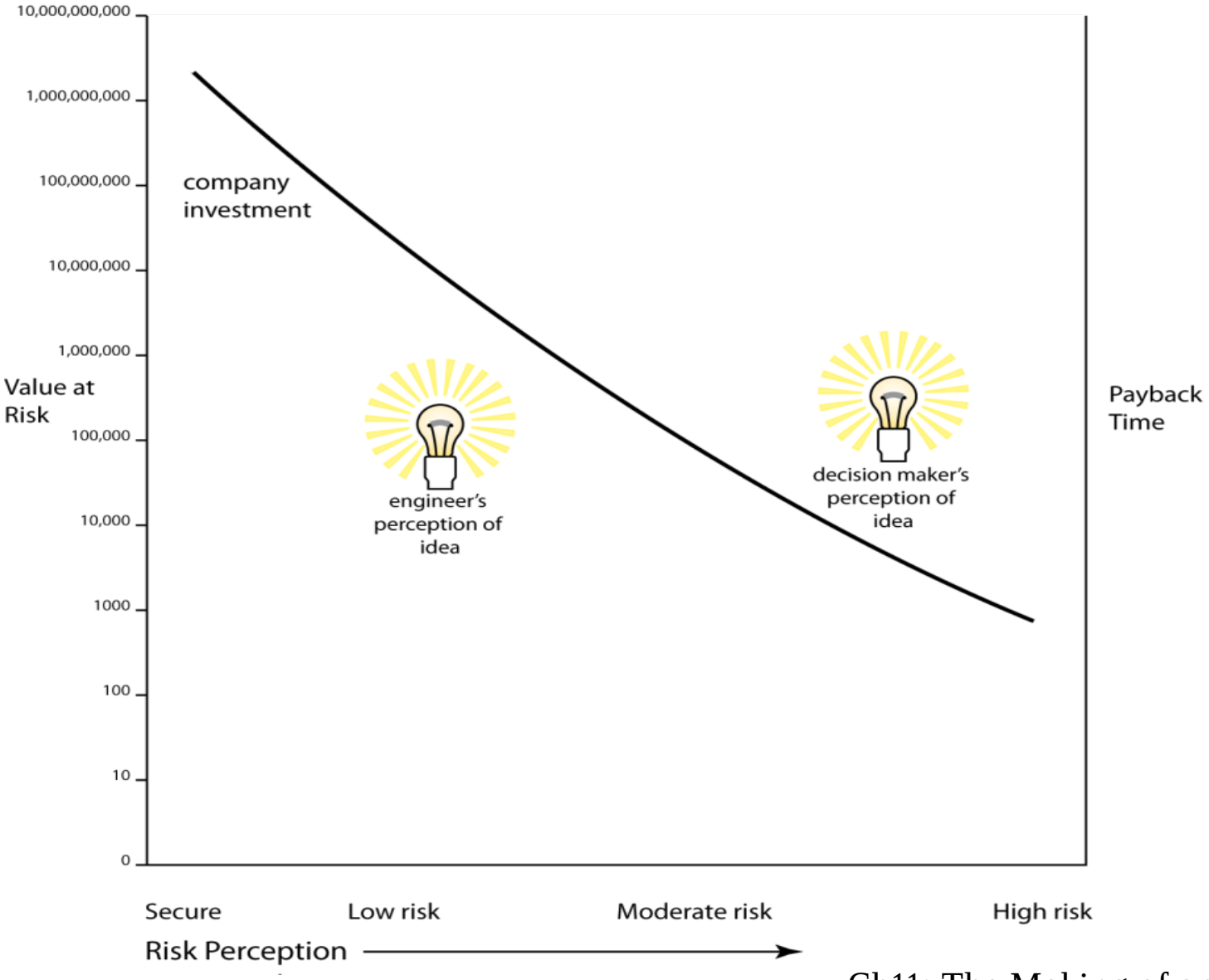
Investor Perceptions of Risk

Ch11: The Making of an Expert Engineer



Perceptions of risk & cost



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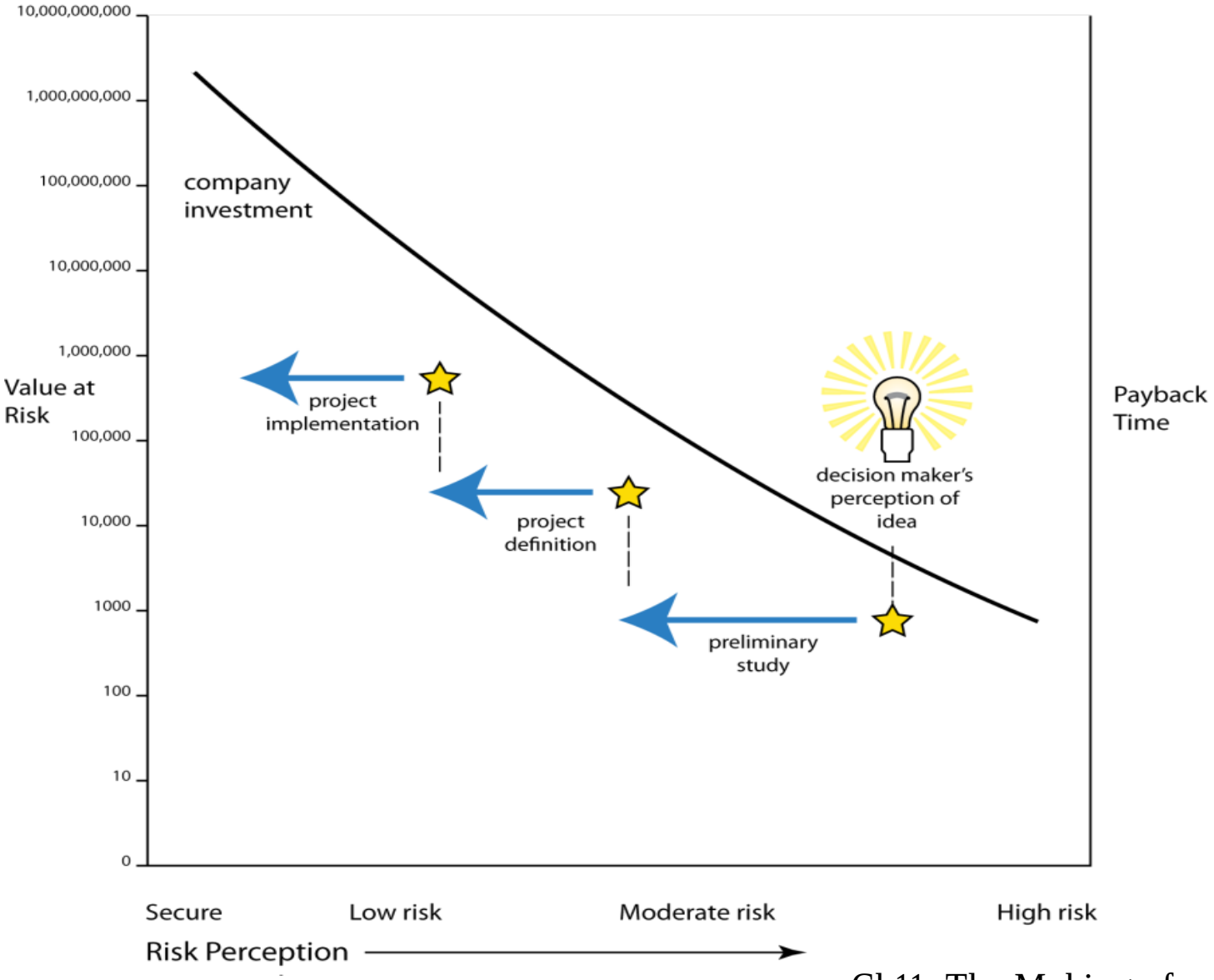
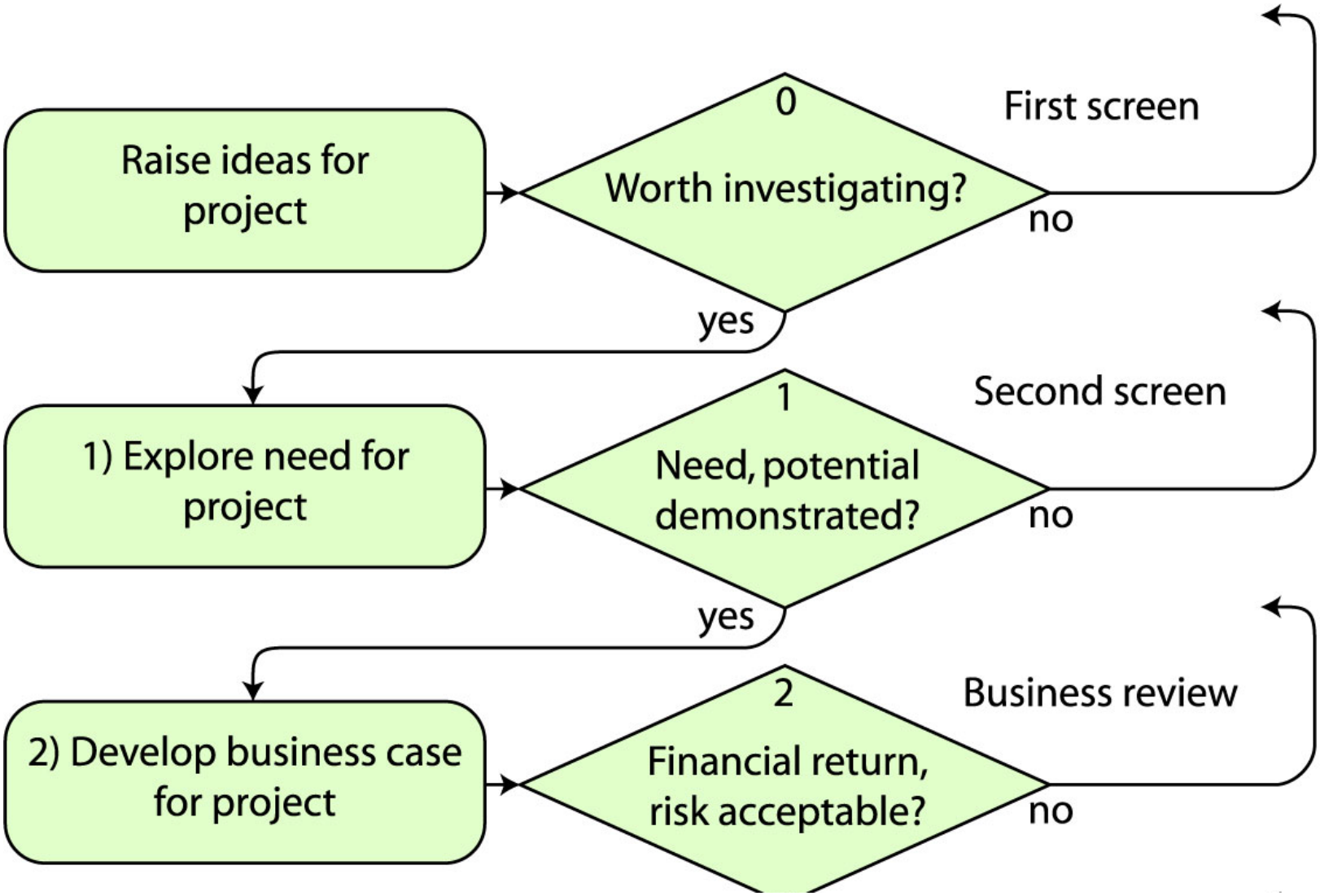


Decision Stage Gate Process for Projects



Capital Project Framework: Front End

5-10% capital cost

- Scoping
  - What is to be done?
  - How?
  - What is the value?
- Planning
  - Approvals, regulatory issues
  - Outline design, construction and procurement etc.
  - Detailed financial planning, estimates, modeling.
  - Final investment decision (FID)

Capital Project Framework: Execution

85-90% capital cost

- Execution
  - Detailed design
  - Procurement
  - Construction
  - Commissioning, approvals for operating
- Operate & Review 100% income
  - Operations & management systems
  - Maintenance, engineering asset management
  - Optimization, capacity upgrades
- Decommissioning 5% capital cost
  - Planning, approvals
  - Re-use, recycling, disposal, rehabilitation

Reducing uncertainty

- Less exciting?
- Less challenging?
- Tolerate lower return
- Tolerate longer payback time
- More capital available

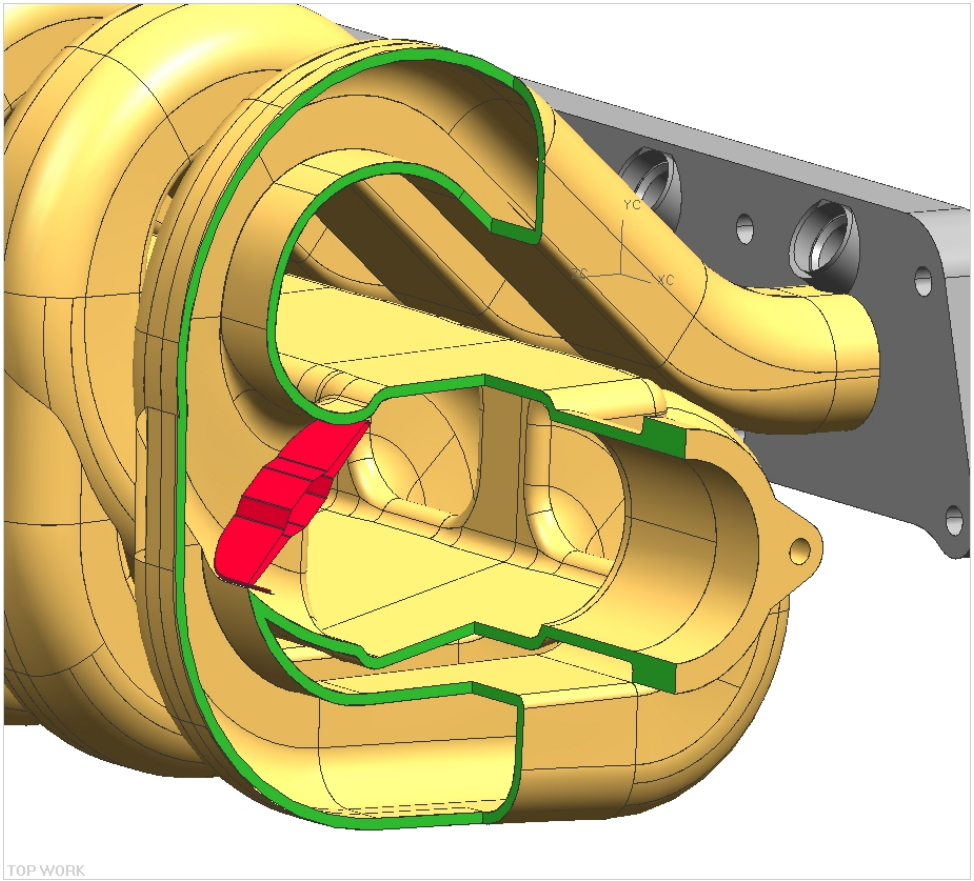
Decision Gates

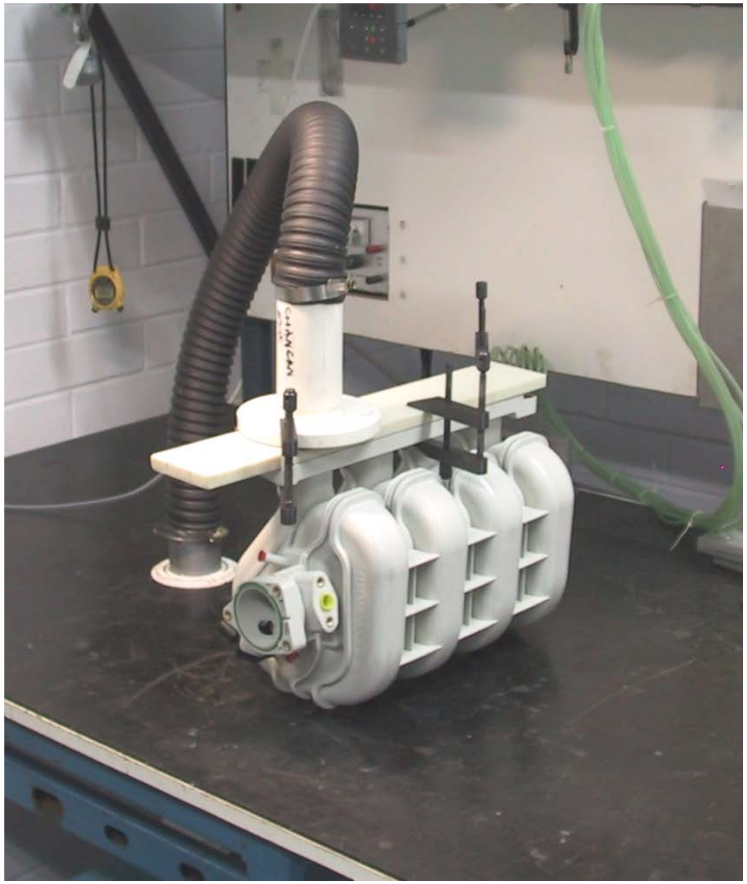
- Between major project stages

  E.g. final investment decision

- Information needed
  - Estimated project cost (CAPEX, OPEX)
  - Uncertainties in cost, time
  - Estimate financial return (income, capital value)
  - Uncertainties in income, time, capital value
  - External reviews (due diligence)

Engine / Vehicle Modelling: Prediction





ORBITAL

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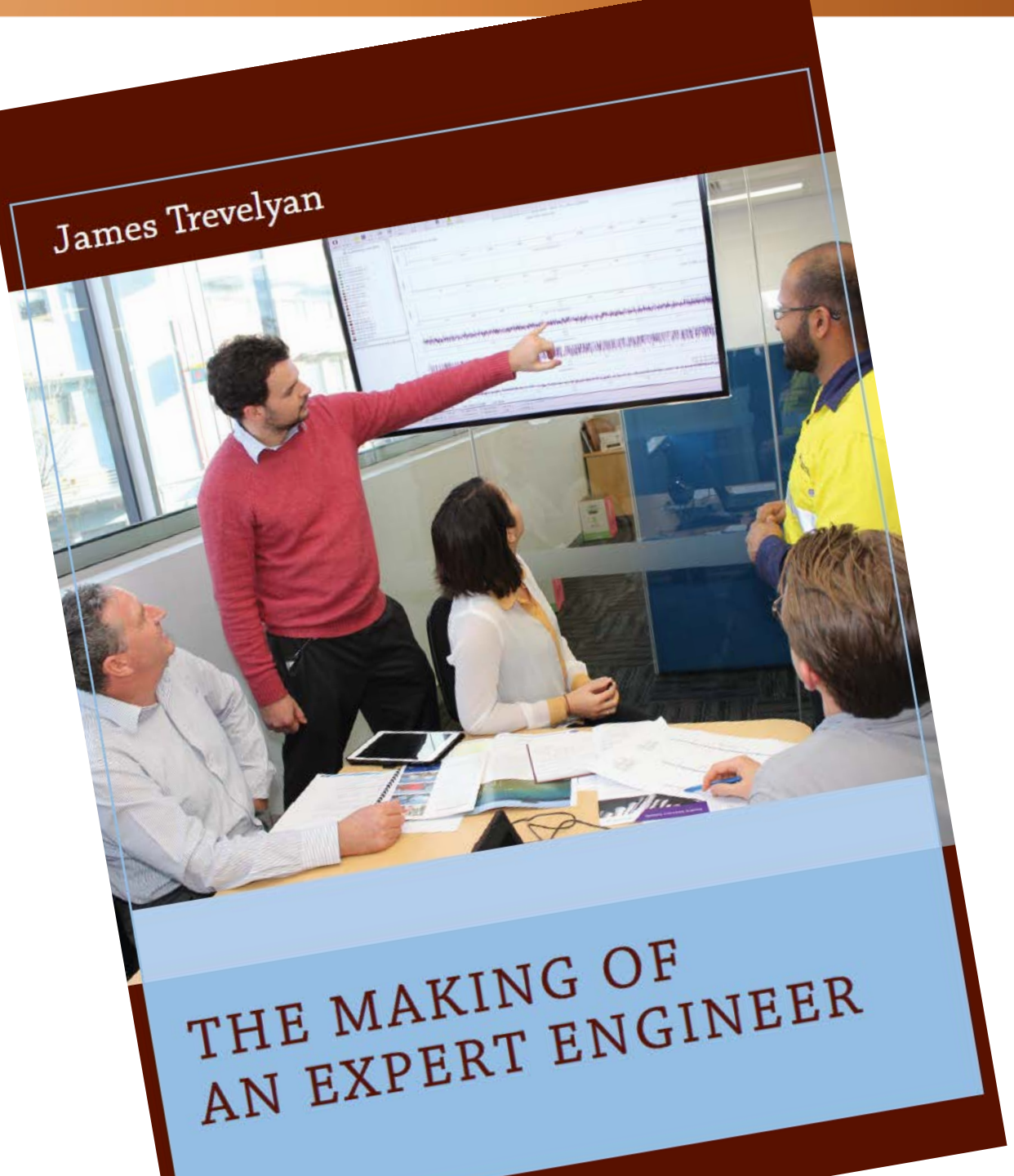
Education Implications 1

- Understanding the purpose of engineering is fundamental
  - Students
  - Engineers
  - Professional Associations
  - Communities
  - Government
- Repetition is needed in many different settings
- Case studies

Education Implications 2

- Understanding technical collaboration as the core of engineering practice
  - Students
  - Engineers
  - Professional Associations
- Repetition is needed in many different settings
- Technical collaboration is complex..... Communication skills (e.g. listening) are only the base layer
- Key to improving value creation performances

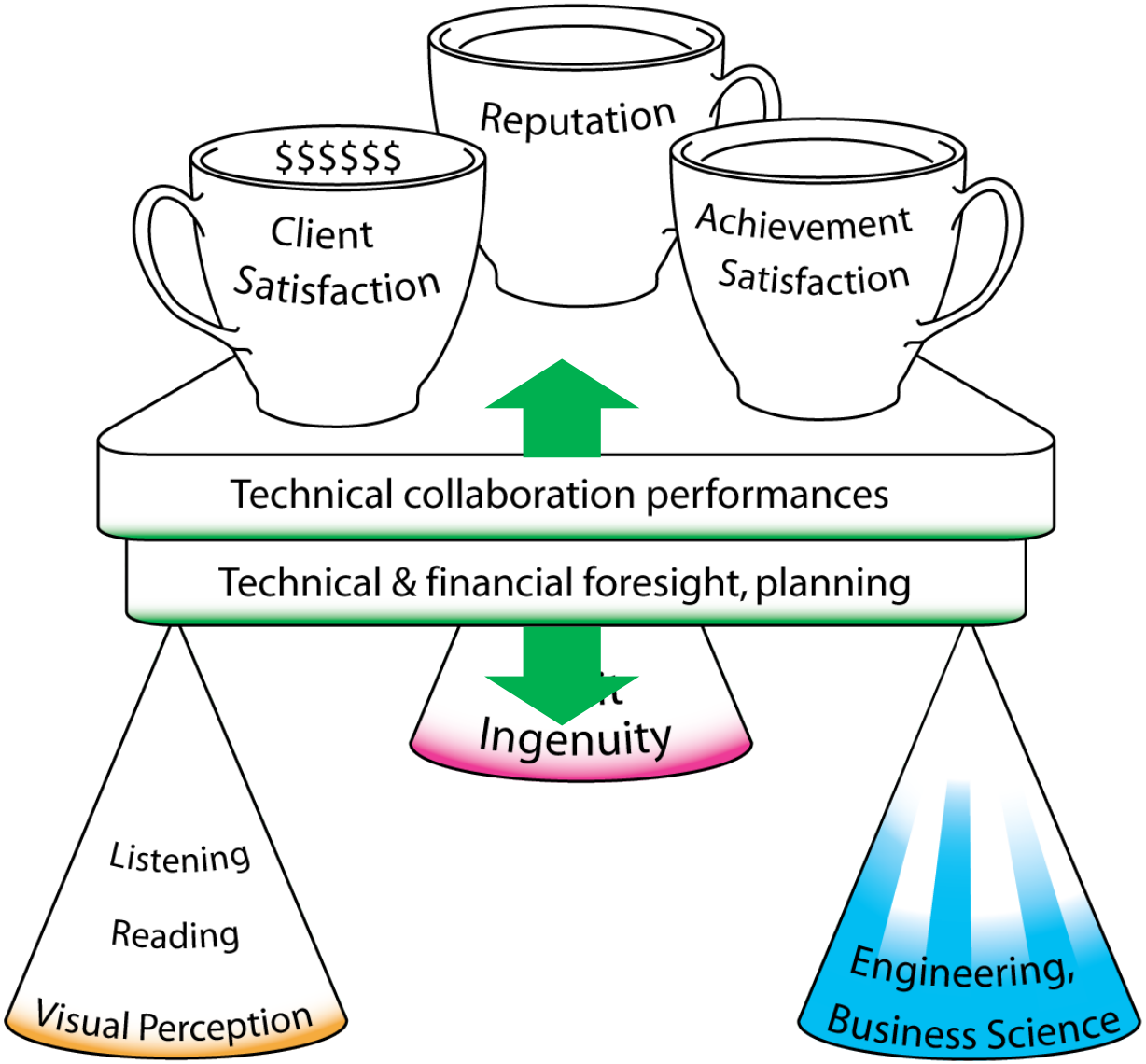


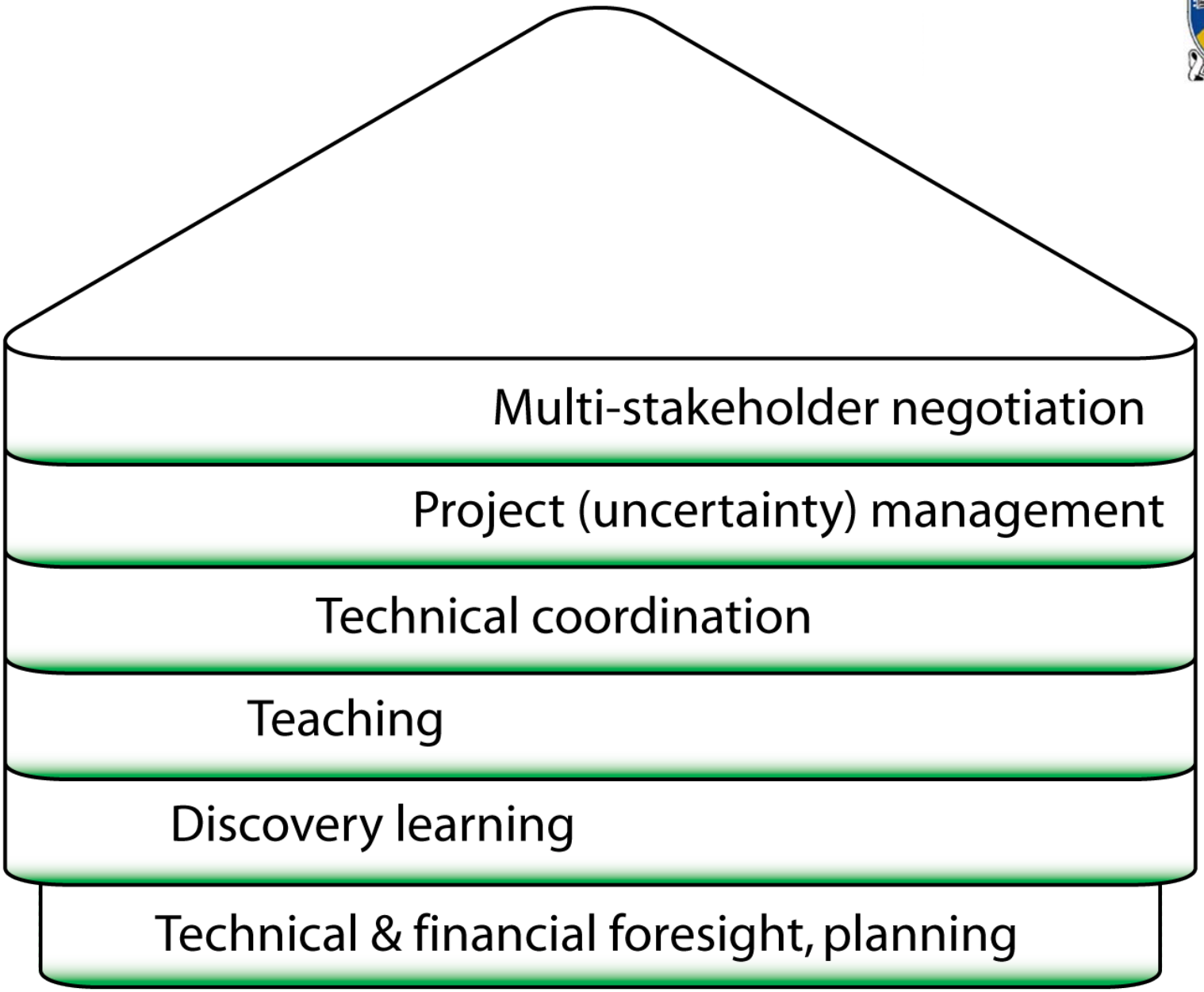
Engineering practice: the work that engineers do that is common to all disciplines.

Knowledge used by expert engineers.

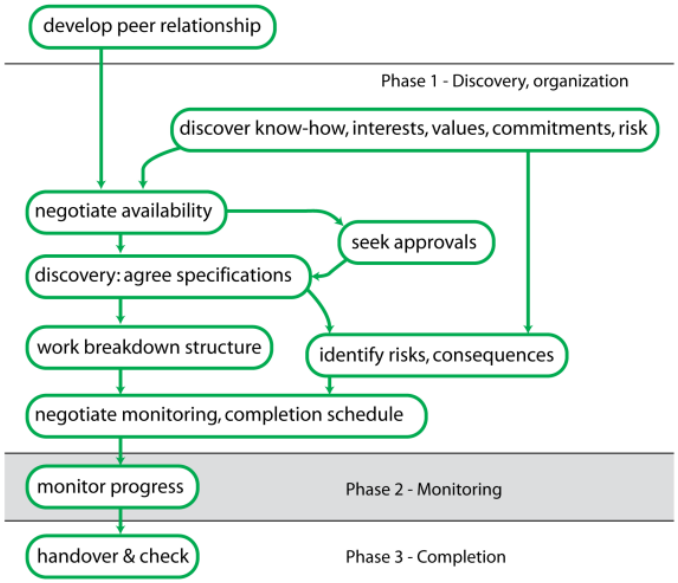
Help younger engineers develop attributes of experts quickly.

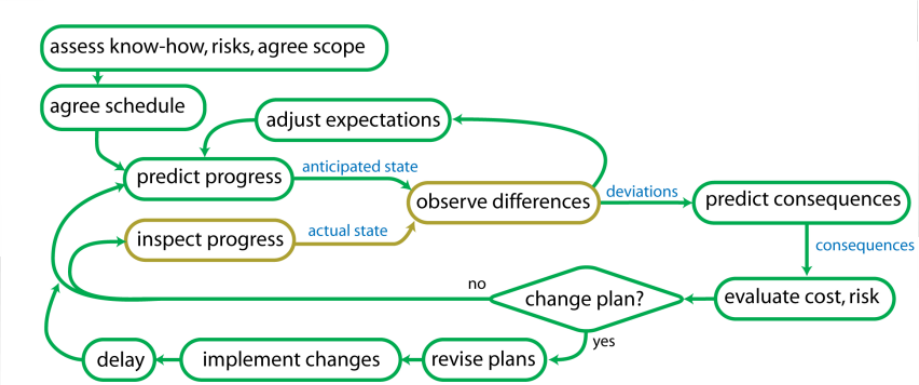
Engineering Practice

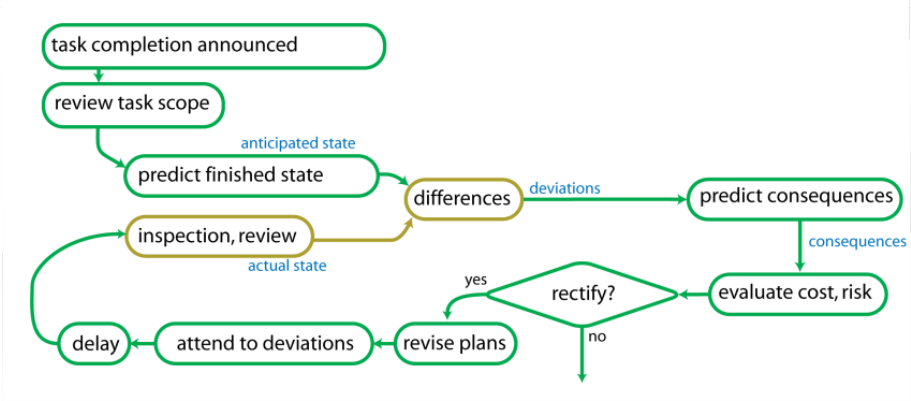



Multi-stakeholder negotiation
Project (uncertainty) management
Technical coordination
Teaching
Discovery learning
Technical & financial foresight, planning

Technical Coordination







Cooperative Learning

- Teach differently: no need for curriculum change
- Emphasizes the social dimensions of learning
- Students learn most from each other
- Demonstrated learning gains in thousands of evaluations
- Learn technical and social at the same time with improved results
- More satisfying teaching

Smith, Karl A., Sheri D. Sheppard, David W. Johnson, and Roger T. Johnson. 2005. "Pedagogies of Engagement: Classroom-Based Practices." Journal of Engineering Education 94 (1):87-101.

Brown, Ann L., Doris Ash, Martha Rutherford, Kathryn Nakagawa, Ann Gordon, and Joseph C. Campione. 1993. "Distributed expertise in the classroom." In Distributed cognitions: psychological and educational considerations, edited by Gavriel Salomon, 188-228. Cambridge: Cambridge University Press.