SUPPORTING ENGINEERING PROFESSIONAL PRACTICE WITH CONTENT AND COMPETENCY

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Overview

• Why is Engineering Professional Practice a problem worth considering?
• Development of manufacturing strategies and paradigms
• Examples
• The “What” and the “How” – Systems Engineering and Lean Engineering
• Impact on engineering education
• Content and competency mastery
• The dirty word – Holistic
• Summary
Communication Failures
ASME Vision 2030 – Early results

- Not important for entry-level
- Weak - but not an entry-level concern
- Weak - needs strengthening
- Sufficient. No Concerns
- Strong
- Strong - but needs even more emphasis

- Information processing (electronic communication)
- Computer modeling/analysis (software tools)
- Technical fundamentals (traditional ME subdisciplines)
- Interpersonal/teamwork
- Problem solving & critical thinking (analysis)
- Communication (oral, written)
- New technical fundamentals (new ME applications)
- Design (product creation)
- Experiments (laboratory procedures)
- Practical experience (how devices are made/work)
- Leadership
- Overall systems perspective
- Engineering Codes and Standards
- Project management
- Business processes
Engineering Professional Practice

Workforce Development
Engineering Education
Life-Long Learning
Problem Solving
Globalization
Safety
Program Development

Faculty Development
Diversity
Systems Thinking
Sustainability
Communication
Ethics
Program Governance

Where are we (ME) teaching (any of) this?
Complexity, not Integration (Source Functions)

- Engineering sciences – the basics
- Engineering mechanical, electrical, optical components into smaller packages
- Cause-effect chains and networks, unknown and not in plain sight
- Airbus A320 / A333 / Boeing 777 / 787
- DWH, Fukushima, HDD, others
- Supplier qualification
Project Execution (Environmental Functions)

- Team work
- Different educational backgrounds and disciplines, conflicting values
- Leadership
- Project
- Communication and appreciation of strategies, risks and their mitigation

- Decision-making culture
Product Development Framework

• Work is carried out in teams
• Team members have various cultural, ethnical, professional backgrounds and specializations
• Different training – different risk awareness / classification
• Teams are not necessarily co-located
• Sequestration (e.g., Google) does not work for all teams
• Non-co-located teams pose huge communication issues
Career Planning / Career Advancement / Leadership (1)

- Graduating from HS: How to envision a career? Who can guide you? Friends, parents, GC?
- Globalization of markets has globalized the workplace, requirements to compete successfully have increased
- International corporations – global recruitment market
- SMEs – need international staff to support their global customers and suppliers
- New types of jobs, previously unknown
- Product innovation
- Talent Management
Career Planning / Career Advancement / Leadership (2)

Solid professional foundation (source function) plus competency to navigate professional environment (environmental function) plus decision-making culture (e.g. leadership skills).
## Development of manufacturing strategies and paradigms

<table>
<thead>
<tr>
<th></th>
<th>Arts &amp; crafts</th>
<th>Mass Prod.</th>
<th>Lean</th>
<th>Agile</th>
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<tbody>
<tr>
<td>Manual Skills</td>
<td>High (5)</td>
<td>Low (2)</td>
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<tr>
<td>Part Quality (interchange)</td>
<td>Low (2)</td>
<td>Medium (4)</td>
<td>High (5)</td>
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<td>Production Flexibility</td>
<td>High (5)</td>
<td>Low (1)</td>
<td>Medium (4)</td>
<td>High (5)</td>
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<tr>
<td>Required Systems Competencies</td>
<td>Low (1)</td>
<td>Low (1)</td>
<td>High (5)</td>
<td>High (5)</td>
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<tr>
<td>Professional Specialization</td>
<td>Low (0)</td>
<td>Medium (4)</td>
<td>Excessive (?)</td>
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The “What” and the “How” – Systems Engineering and Lean Engineering

• Systems Engineering - “an interdisciplinary approach and means to enable the realization of successful systems” (INCOSE)
• Defining customer needs, required functionality, documentation
• Systems Engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs
• Design synthesis and system validation while considering the complete problem: Operations, Performance, Test, Manufacturing, Cost & Schedule, Training & Support, and Disposal.
• Systemic break-up of project into hierarchical structure
• Unknown cause-effect chains
Where Content meets Competency

**Systems Engineering**
- A system is not 100% deterministic
- System may not follow reductionist approach
- Focused on technology
- Engineering Sciences and Basic Sciences

**Lean Engineering**
- Purpose, process, people
- Workforce development
- Continuous evolution
- Teamwork

Source Functions

Environmental Functions

CONTENT

COMPETENCIES
Case Studies

- CPT airport
- On-site machining
- Health care

- Why has it worked?
Non-contact Measurements – Baggage Sortation at CPT

Condition:
- Frequent break-downs
- Low throughput
- Slow
- Safety

Outlook for 2010
World Cup:
Not suitable
Baggage Sortation at CPT (2)

- Throughput demands automation of the BSF (length of several km)
- 24 / 7 operation at peak times
- Real-time preventive maintenance and condition monitoring
- Automatic identification and localization of impending malfunctions
- Escalating safety levels
### Baggage Sortation at CPT (3)

<table>
<thead>
<tr>
<th></th>
<th>Vibration Analysis</th>
<th>Oil Debris Analysis</th>
<th>Thermal Imaging</th>
<th>Balancing &amp; Alignment</th>
<th>Performance Monitoring</th>
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<td>Belts</td>
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<td>Electric Motors</td>
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<td>Frame</td>
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<td>Gearboxes</td>
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<tr>
<td>Rollers</td>
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</table>

- 200 separate conveyor belts, at least one motor each
- Motor damage mostly due to defective bearings and damage to electrical insulation
- Maladjustments during installation or due to shocks during operation
- Breakdown of lubrication
- Limited access to damaged rollers / damage not obvious; proof often indirect (bearing conditions)
On-Site Circular Milling

- Portable machine tool
- Assembled on-site, mounts directly to work.

- Re-aligned to work for each job.

- Primary use: finishing slewing bearing seating surfaces to within set un-flatness tolerances.
Metrology Challenges

- Aim: To reduce the combined Un-flatness and taper error.
- Reduce localised stresses in slewing bearing raceways.
- Decreased fatigue in bearing.
- Increased in service lifespan.
- Potential for larger load capacity.
Self-Organization – Medical Service Delivery

A horizontal journey through a vertical enterprise.

Ben-Tovim et al. 2003
Flinders Medical Centre

Arrive ↔ Patient ↔ Discharge

Register

Clinical Assessment

Decision

Rx

Investigation

Process Responsibility

Clinical Responsibility

Communication Responsibility

Redesigning Care: improving the patient journey
Case Studies (Pittsburgh)

Allegheny GH:
- # of patients with intraveneous infections: 37 -> 6
- Associated deaths: 19 -> 1

Southside Hospital:
- Time spent searching for meds: -60%
- Stock-outs: -85%

Shadyside Hospital:
- Estimated nurse time spent on patient-controlled anaesthesia pumps: -2900 h p.a.
Adverse effects of prosthetic wear debris include:

- Prosthetic structural failure
- Biological incompatibility
  - Toxicity
  - Osteolysis

Why has it worked?
LEARNING PROCESS
Holistic Development

SELF
Triggers

Delayed Gratification

Trust

CONFIDANTS

Risk

Complexity

OTHERS
Self-Actualization

Praxis

Confusion

Stress
## Barriers to Holistic Development

<table>
<thead>
<tr>
<th>Category</th>
<th>Examples</th>
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</thead>
<tbody>
<tr>
<td>Poor Management Philosophies</td>
<td>• Theory X • Scientific Mgt</td>
</tr>
<tr>
<td>Structures</td>
<td>• Domination • Silos</td>
</tr>
<tr>
<td>Wasteful Traditions</td>
<td>• Typecasting • Lack of incentives</td>
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</tbody>
</table>
Mass Production Paradigms

- Allocation of Power, Space, Conditions
- Roles, Duties
- HR Policy, Rules
- HR Philosophy, Culture
Lean Production Paradigms

- Allocation of Power, Space, Conditions
- Roles, Duties
- HR Policy, Rules
- HR Philosophy, Culture
LEAN LEARNING SYSTEMS
Transformational

- CANONS
  Body of Knowledge
  Contracted
  Transactional

- STANDARDS
  Taught
  Expected
  Didactic
  Outside/In

- NORMS
  Developed
  Hoped For
  Socratic
  Inside/Out

- COMPETENCIES
  Body of Practice
  Internalized
  Transformational

  THINKING

  DOING
PARADIGM SHIFT:
HOLISTIC DEVELOPMENT
DOUBLE HELIX DNA

CONTENT

COMPETENCIES
Content & Competency Development

Holistic Taxonomy

SELF
CONFIDANTS
OTHERS
Holistic Taxonomy of Development

Head
- KNOWLEDGE
- CONTENT & COMPETENCIES

Heart
- DISPOSITIONS
- CONTENT & COMPETENCIES

Hands
- APPLICATIONS
- CONTENT & COMPETENCIES

SELF
CONFIDANTS
OTHERS
<table>
<thead>
<tr>
<th>LEADERSHIP LEARNING: KNOWLEDGE DEVELOPMENT</th>
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<tbody>
<tr>
<td>Talk with others about leadership ideas and seek support, criticism</td>
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<tr>
<td>Seek to understand what others know about leadership</td>
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<tr>
<td>Examine leadership mistakes and how to improve</td>
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<tr>
<td>Use new language, strategies, ideas to solve, mediate, manage change or connect theory to general settings</td>
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<tr>
<td>Learn from a mentor</td>
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<tr>
<td>Read, research, talk, observe if leadership theories have personal relevance and relate to my prior knowledge</td>
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<td>Lead in new ways based on theory, research or documentation</td>
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<td>Discuss potential results of new concepts with family, peers, allies, leaders</td>
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<td>Understand leadership constructs to influence others, share information where some are unfamiliar</td>
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<tr>
<td>Contemplate leadership expectations/ plan how to use concepts, strategies, decision making strategies</td>
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<td>Talk informally, “hallway talk,” about leadership</td>
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<td>Compare personal leadership knowledge with scholarly work, test for validity, evidence, robustness</td>
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<td>Take notes, journal, self-talk about leadership</td>
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<td>LEADERSHIP LEARNING: VALUES DEVELOPMENT</td>
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<td>Construct personal meaning of values by expression and quoting others</td>
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<td>Consider depth of personal relevance, benefits/values, costs/risks of leadership</td>
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<td><strong>Self-direct leadership development activities</strong></td>
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<td>Develop original ideas and share those with stakeholders</td>
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<td>Establish new boundaries in professional, personal relationships by taking risks to advance leadership</td>
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<td><strong>Inspire others to lead</strong></td>
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<td>Self-reflect on dispositions and aligning actions of leadership</td>
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<td>Talk with others noting benefits of sharing about leadership problems</td>
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<td>Identify leadership disposition strengths/weaknesses</td>
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<td>LEADERSHIP LEARNING: APPLICATIONS DEVELOPMENT</td>
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<td>-----------------------------------------------</td>
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<tr>
<td>Have confidence in my ability to lead</td>
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<td>Self-analyze, self-develop, self-evaluate how/when to lead, grow/change</td>
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<tr>
<td>Motivate self to pursue more leadership as others rely on me</td>
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<tr>
<td>Admit when wrong, share apologies</td>
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<td>Lead from experience</td>
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<td>Survey stakeholders assessing my leadership to set goals</td>
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<td>Receive compliments, expressions of confidence by others</td>
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<td>Discuss leadership with my family</td>
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<td>Level</td>
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<td>Knowledge</td>
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## HOLISTIC DEVELOPMENT

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<tr>
<th></th>
<th>SPECIFIC COMPETENCY</th>
<th>SPECIFIC CONTENT</th>
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<tr>
<td><strong>SELF</strong></td>
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<td><strong>CONFIDANTS</strong></td>
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<td>Application</td>
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Competency Development in Industry

- Managerial Ladder
  - People Leadership
  - Individual Contribution
- Technical Ladder
  - Technical Leadership
Competency Development in Industry

- Results
- Behaviors
- Competencies

Performance
## Competency Development in Industry

### Competencies

<table>
<thead>
<tr>
<th>Job Function X</th>
<th>Job Family X</th>
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<tr>
<td></td>
<td>Competencies</td>
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<td>identified</td>
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<td>and maintained by each</td>
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<td>job family</td>
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### Generic Description

<table>
<thead>
<tr>
<th>Job Level</th>
<th>Competency 1</th>
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<th>Competency 5</th>
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### Proficiency Levels

- Expert
- Proficient
- Intermediate
- Novice
- Limited
Summary

• Competency Development is biggest challenge in workforce development
• Work in non-co-located teams is reality
• Main Challenges: Silos, Communication, Visualization, Leadership, Decision-Making
• Ethnical, cultural, value-related, gender gaps and departmental barriers must be bridged
• Content (Systems Engineering) and competency (Lean Engineering) cannot be regarded as separable