Innovative Strategies for Effective System Engineering Training

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Background

- The need for trained systems engineers is steadily increasing

- Wide variations exist in the style and content of systems engineering training

- This presentation will highlight these differences, and offer innovative strategies for ensuring systems engineering training is effective
  - Target audience
  - Body of knowledge
  - Delivery format
  - Student-centered learning
  - Case studies
Key Questions in Establishing SE Training

• What topics should be addressed?
  – Technical, process, organizational, contextual?

• Should training be developed in-house or bought from a vendor or university?

• Are alternatives to classroom training effective? Under what conditions?
  – Mentoring, on-line, guided self-study, on-the-job?

• How should training be paid for?

• How do you determine whether training is effective?

• How much SE training is enough?
Who is the Target Audience?

Junior SEs and component engineers
  – Seeking to broaden their understanding of SE, as it applies to their tasks

Support personnel
  – Seeking to understand SE, to support more effectively

Senior SEs
  – Seeking to effectively manage the SE process

- Student background and experience
- Student expectations
- Overhead vs. student time
Is the Staff Qualified to Do Their Work?

What are the minimum skills and knowledge needed to perform their job function?

Does each individual possess these skills?
- If not, training should address the gaps

An organizational responsibility!

How does the organization maintain a skilled and knowledgeable workforce?
Competency Model

• A competency is a set of behaviors encompassing skills, knowledge, abilities, and personal attributes critical to successful performance at a particular job
  – Should be observable and measurable through behaviors
  – These behaviors provide a model for superior job performance
• Can provide a powerful mechanism for identifying gaps in individual and workforce-wide skills sets, identify appropriate training
• Must be integrated with an organization’s strategic goals and individual performance plans
Strategies for Organizational Training

- Start by defining the key job functions in the organization
  - E.g., project manager, software engineer, quality assurance specialist

- Identify the requisite knowledge associated with each function

- Define a set of course modules that impart this knowledge
  - Map modules to job functions
  - Some modules will be common to multiple job functions

- Acquire training materials and trainers
  - Should reflect the organization’s policies and processes
  - Unlikely that standard vendor/university courses will fit
Strategies for Organizational Training - 2

- Identify each employee by their job function(s), map to required courses
  - If the employee already has the identified minimum knowledge, they do not need to take the course
- Establish student records
  - Who has completed what course, waivers
- Review required training with employees
  - Career-planning, promotions, new hires
- Add project-specific training (e.g., tools, methods), where needed
Body of Knowledge

Government/commercial standards (e.g., MIL-STD-499C, INCOSE SE Handbook, SEBoK, …)

System engineering discipline vs. engineering a system

Organizational-specific topics
- Processes and procedures
- Tools and methods
- Customer acquisition practices
- Domain-specific technologies
Andragogy - Learning strategies focused on adults

- **Need to Know** - Adults need to know the reason for learning something
- **Foundation** - Experience (including error) provides the basis for learning activities
- **Self-concept** - Adults need to be responsible for their decisions on education; involvement in the planning and evaluation of their instruction
- **Readiness** - Adults are most interested in learning subjects having immediate relevance to their work and/or personal lives
- **Orientation** - Adult learning is problem-centered rather than content-oriented
- **Motivation** - Adults respond better to internal versus external motivators

Student-Centered Learning

Traditional Instructor-Led

- Instructor as recognized authority, constant lecturer, and master of the classroom
  - Student as passive receptor
- Instructor presents course content primarily through lecture
- Assessment verifies that course content was memorized

Student-Centered Learning

- Student is responsible for their own learning, proactively identifies gaps in knowledge, how best to learn
  - Teacher as guide
- Goal is for the student to develop the skills needed to explore and use the information
- The student explores and applies content, with instructor and fellow students providing feedback
Student-Centered Teaching Styles

- Read-ahead material
- References for further study
- Students help identify topics, depth of instruction
- Students review material and teach others
- Class projects
- Case studies
Case Studies

• Case studies provide an opportunity for students to see the real-life application of SE principles and tools
  – Bad examples often just as instructive as good examples

• Require participation and integration of a broad set of skills
USAF SE Case Studies

http://www.afit.edu

• A-10 Thunderbolt
• B-2 stealth bomber
• C-5 military transport
• E-10A MC2A aircraft
• F-111 aircraft
• Global Hawk drone
• Global Positioning System (GPS)
• Hubble Space Telescope
• International Space Station
• KC-135 simulator
• Large Aircraft Infrared Countermeasures
• MH-53J/M PAVE helicopter
• T-6A Texan II aircraft
• Theater Battle Management Core System (system-of-system command and control)

<table>
<thead>
<tr>
<th>Responsibilities</th>
<th>Contractor</th>
<th>Shared</th>
<th>Govt.</th>
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</thead>
<tbody>
<tr>
<td>Requirements Definition and Mgmt</td>
<td></td>
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<tr>
<td>Systems Architecture Development</td>
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<td>Validation and Verification</td>
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<td>Deployment and Post Deployment</td>
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Lessons Learned

• Student individual motivations greatly effect the degree of learning

• The classroom setting provides a low risk environment conducive to learning

• Students value an understanding of the overall SE process and an SE perspective

• Class projects provide practical feedback on implementation details, team dynamics

• SE training can encourage further study and connections with other functional areas on the students’ current project
THE VALUE OF PERFORMANCE.

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