The Emergence of New Knowledge Engineering Disciplines

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New Engineering Disciplines

- Logistics Engineering
- Risk Engineering
- Neural Engineering
- Delivery Engineering
- Safety or Security Engineering
- Bioengineering
- Biomedical Engineering
- Assistive (Life support) Engineering
- Synthetic biology Engineering, ..
New **Knowledge** Engineering disciplines:

- Software Engineering
- Data Engineering
- Knowledge Engineering
- Web Engineering
- Systems Engineering
- Value Engineering
- Information Technology Engineering
Presentation Objectives

- Understand how a civil society develops & supports an engineering discipline
- Understand the core of an engineering discipline: its body of knowledge
- Understand how to develop quickly a consensus on an engineering body of knowledge
- Identifies opportunities for improving/consolidating new Knowledge Engineering disciplines
List of topics

1. Engineering products and services: What do you expect?
2. The framework of an engineering discipline in a society
3. A body of knowledge: From anarchy to a society’s consensus: the SWEBOK project
4. Software Engineering: Fundamental Principles?
5. Conclusions?
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1- Engineering Products and Services: What do you expect?

- Bridges
- Airplanes
- Airports
- Trains
- Electricity delivery
- Medical devices
What happens when it does not work as engineering devices?

1. Bridges
2. Airplanes
3. Airports
4. Trains
5. Electricity delivery
6. Medical devices
1- Engineering Products and Services: What do you expect?

What do you expect from an engineer?

- ??
1- Engineering Products and Services: What does society expect from an Engineer?

Bridge built in 1971: collapsed in 2006!

- 2007 Government Inquiry Outcomes:
  - Lack of details in engineering plans on multiple types of steel
    - But according to knowledge & standards known in 1971
  - Faulty implementation in 1971
    - Faults assigned to:
      » Contractor-builder firm & executives
      » Steel supplier & executives
      » Consulting Engineering firm & executives
      » Engineer in charge of supervision
1- Engineering Products and Services: What does society expect from an Engineer?

- Government enquiry (Cont’d 2):
  - Poor quality of cement used
    - No blame assigned due to lack of documentation
  - Other causes:
    - Vulnerability to some types of ‘cisaillement’
      » Recommendation to improve standards
  - Lack of impermeability in 1992 led to inspection & repairs
    » Some intrusive tests led to further weaknesses
    » Engineer faulted for poor diagnostic and poor management of the 1992 repairs
1- Engineering Products and Services: What does society expect from an Engineer?

Government enquiry (Cont’d 3):

- 2004 Inspection:
  - Inspector in charge of regular inspections requested further technical help
  - **Expert engineer** called in:
    » did not carry other specialized analyses
    » But had not access to 1992 study report
  - Engineer faulted
  - Government faulted for lack of adequate oversights:
    » *in documentation management, incomplete plans, incomplete quality assurance plans, ambiguity in accountability responsibilities between individuals and administrative units*
1- Engineering Products and Services: What does society expect?

Lessons learned:

- **Professional engineer:**
  - Professional rigor
  - Expertise and discipline in execution
  - Curiosity in investigating **causes** of damages found in inspections should be **overriding**

- **Engineering firms:**
  - Accountability of engineering firms on inspection and decision making on follow-up
  - Necessity to adapt inspection systems to context and types of products and services
1- Engineering Products and Services: What do you expect?

What do you expect from an Engineer and of an Engineering firm?

- Technical & Legal accountability of:
  - Engineering plans
  - Execution of plans & use of adequate resources
  - Quality assurance of execution
  - Quality assurance of maintenance & inspections
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4. Software Engineering: Fundamental Principles?

5. Conclusions?
Recognized Profession?

  - Knowledge and competence **validated by the community of peers**
  - Consensually validated knowledge **rests on rational, scientific grounds**
  - Judgment and advice **oriented toward a set of substantive values**
Model of the Maturity of a Profession

- Ford and Gibbs:
  - Education
  - Accreditation
  - Skills development
  - Licensing/certification
  - Professional development
  - Code of ethics
  - Professional society or societies

Professional Development

Professional Development

- Initial professional education
- Skills Development
- One or both Certification Licensing
- Full Professional Status

Infrastructure Support for the Profession

- Accreditation
- Professional development
- Code of ethics

Professional Society Influence

Professional societies

Adapted from Steve McConnell, *After the Gold Rush*, Microsoft Press, 1999, p. 93
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3- A new body of knowledge?

Is Software Engineering an Engineering DISCIPLINE?
3- A new body of knowledge: from anarchy ...

- The identification of a need from weaknesses
  - The new term emerges early: 1968
- A plethora of initial proposals...
  - and claims
  - Characterized by individual proposals
- Local views in the late 90’s:
  - multiple schools of thoughts
3- A new body of knowledge: from anarchy ...

- **Researchers** investigate new topics:
  - new knowledge but based on very small scale experiments (when there is some..!)

- **Industry leaders** also develop world class solutions & knowledge:
  - Large scale
  - System wide
  - Support services
  - Relatively high quality
    - ...but far from perfect and at high risks and costs
3- A new body of knowledge: from anarchy

Industry leaders - **but**: 

- Develops expertise *internally*
- Develops internal **system knowledge**:  
  - Procedural know-how & technologies
- Take **years to train staff**
- Keeps specialized knowledge as **trade secrets** for **competitive edge**
3- A new body of knowledge: from anarchy

And:

- How do you train & develop young people skills and knowledge in a regular engineering program in a university setting:
  - Without access to trade secrets?
  - Without requiring years of practice after graduation?
A Core Body of Knowledge & Relationships in an Engineering Discipline

- Development of Software Engineering Curricula
- Consensus on a Core Body of Knowledge
- Development of Certification / Licensing Criteria and Exams
- Development of University Program Accreditation Criteria
Window of Opportunity?

- Texas Board of Professional Engineers & IEEE
- Others:
  - ACM/IEEE-CS Code of Ethics
  - Degrees in Software Engineering
    - Computer Science Curriculum 2001
    - Rochester Institute of Technology (and others) offering undergraduate degrees
  - CSAB & ABET are cooperating on accreditation
  - Possible software liability issues
  - Increased interest in the establishment of a profession (After the Gold Rush was #752 on Amazon.com)
  - Continuing focus on organizational engineering capability (ISO 9000, CMM)
SWEBOK Project Objectives

- Promote a consistent view of software engineering worldwide
- Clarify the place of, and set the boundary of, software engineering with respect to other disciplines
- Characterize the contents of the Software Engineering Body of Knowledge
- Provide a topical access to the Software Engineering Body of Knowledge
- Provide a foundation for curriculum development and individual certification and licensing material
SWEBOK Intended Audiences

- Public and private organizations
- Practicing software engineers
- Makers of public policy
- Professional societies
- Software engineering students
- Educators and trainers
What is Software Engineering?

IEEE Std 610.12:

(1) The application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software; that is, the application of engineering to software.

(2) The study of approaches as in (1).
## Categories of Knowledge in the SWEBOK Guide

<table>
<thead>
<tr>
<th>Specialized</th>
<th>Generally Accepted</th>
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<tr>
<td></td>
<td>Advanced and Research</td>
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Focus of the SWEBOK Guide
Software Engineer’s Knowledge

Knowledge of a Software Engineer

- Application domain knowledge
- Advanced SE Knowledge
- Specialized SE Knowledge
- SWEBOK
- C.S.
- Maths
- ...
Corporate Support by:
Two Underlying Principles of the Project

- **Transparency:** the development process is itself published and fully documented
- **Consensus-building:** the development process is designed to build, over time, consensus in industry, among professional societies and standards-setting bodies and in academia
Project Team

- Editorial team
- Industrial Advisory Board
- Knowledge Area Specialists
- Reviewers
Editorial Team

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Robert Dupuis
Université du Québec à Montréal

Executive Editors

Guide Editors
A Three-Phase Approach for Developing the Guide

- Straw Man Version
- Stone Man Version
- Iron Man Version (Sub-phase 1)
- Iron Man Version (Sub-phase 2)
Review Process

- Transparency and consensus-building
  - All intermediate versions of documents are published and archived on www.swebok.org
  - All comments are made public as well as the identity of the reviewers
  - Detailed comment disposition reports are produced for Review Cycle 2 and 3
  - Roughly 5000 comments from 200 reviewers in 25 countries
Deliverables

- **Consensus** on a list of Knowledge Areas
- **Consensus** on a list of topics and relevant reference materials for each Knowledge Area
- **Consensus** on a list of Related Disciplines
- Available free on the web
Baseline List of Knowledge Areas

- Requirements
- Design
- Construction
- Testing
- Maintenance
- Configuration Management
- Quality
- Engineering Tools & Methods
- Engineering Process
- Engineering Management

Related Disciplines

- Computer Science (CC2001)
- Mathematics (CC2001)
- Project Management (PMBOK)
- Computer Engineering
- Cognitive Sciences and Human Factors
- Systems Engineering
- Management and Management Science
How long does it take to develop a consensus to be recognized as an engineering discipline?

- + 1,000 years: civil engineering
- + 40 years: aeronautical engineering

Software Engineering?
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4- Software Engineering: Fundamental Principles?

Is Software Engineering an Engineering Discipline?
Fundamental Principles of Software Engineering

Work to date & in progress:

- Relationships: Standards & Principles
- Delphi Studies
- Principles Criteria
- Engineering criteria
Standards Strive to Balance Principles and Practice

Standards strive to integrate and organize strengths of *a priori* principles with ‘best’ practices observed in the messy real-world.

In many disciplines, *a priori* considerations are provided by science and mathematics. Sometimes they are provided by ‘traditions’ or by market forces. In software engineering, there is no agreement on such *a priori* and we have to discover and figure out what are its principles.
We have to invent 'what'?

LOG, 8/20/2007
Fundamental Principles of Software Engineering

A collaborative effort: IEEE Computer Society & Université du Québec (UQAM-ETS)

- **SWE Principles** are specific cases of general engineering principles.
- **SWE Principles** organize, explain and validate the practice standards.
- Practices are deployed based on the practice standards.

Some SWE Principles may be generalized to principles for the engineering of complex systems. SWE Principles should be “abstractions” of practice standards. Practice standards should be recordings of observed best practices.

Source: [Jabir97]
1996-1998 Delphi Studies

Decision of the IEEE Software Engineering Standards Committee

Recommendation to identify fundamental principles of software engineering

Criteria for identifying and evaluating proposed principles

Delphi I: International Software Engineering
Criteria: Principles must be ...

- Less specific than methodologies
- More durable than methodologies and techniques
- Extracted from practice
- Linked to at least one underlying concept of SE
- Not involve a trade-off
- Be specific enough to be able to demonstrate experimentally that not applying the principle leads to bad consequences (e.g. undesirable outcomes).
L2

Est-ce le bon mot en anglais?

LOG, 8/20/2007
2003-2006 Séguin Study

- From the literature survey = 300 proposals principles
  - Activities
  - Prescriptions
  - Descriptions, etc.
- Identification of criteria to recognize a principle
- Outcome: 34 candidate principles meet the ‘principles’ criteria (See Séguin 2006)
Meridji 2007+ Study

Phase 1
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Software Engineering Today

Professional Development

Initial professional education

Skills Development??

One or both

Certification  Licensing

Full Professional Status??

Infrastructure Support for the Profession

Accreditation

Professional development

Code of ethics

Professional Society Influences

Professional societies

New Engineering Disciplines

Knowledge Engineering disciplines:

- Data Engineering
- Knowledge Engineering
- Web engineering
- Systems Engineering
- Value Engineering
- Systems Engineering
- Information Technology
Other New Engineering Disciplines: How do they stack up today?

Professional Development

- Initial professional education
- Skills Development
  - One or both
    - Certification
    - Licensing
  - Full Professional Status

Infrastructure Support for the Profession
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Questions
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