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 Engineering Disciplines

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?

List of topics

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5. Conclusions

1- Engineering Products and Services: What do you expect?

- Bridges
- Airplanes
- Airports
- Trains
- Electricity delivery
- Medical devices

1- Engineering Products and Services: What do you expect?

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**
    - **Goverment 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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5. Conclusions?

Recognized Profession?

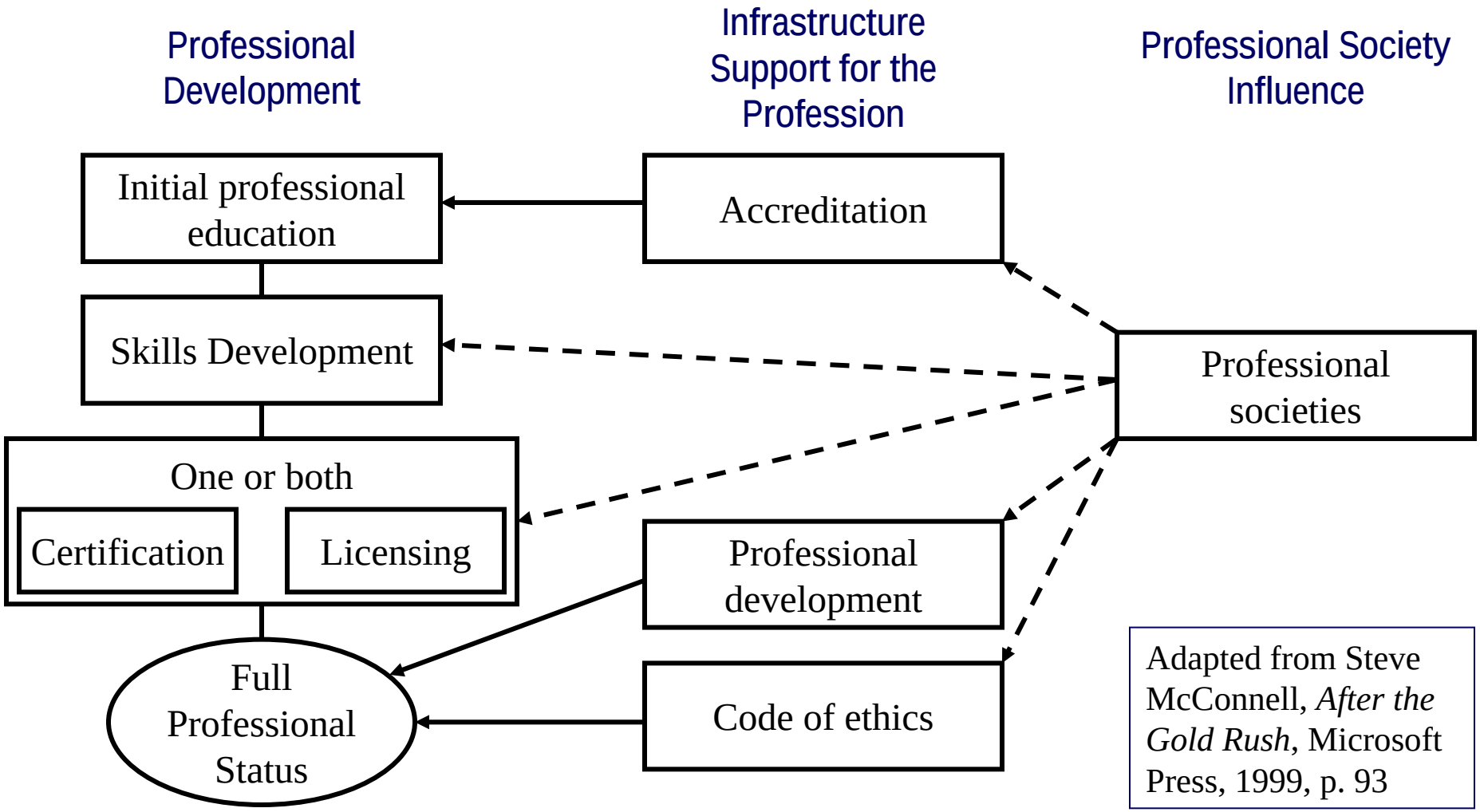
- P. Starr, *The Social Transformation of American Medicine*, BasicBooks, 1982:
  - Knowledge and competence **validated by the community of peers**
  - Consensually validated knowledge **rests on rational, scientific grounds**
  - Judgment and advice **oriented toward a set of substantive values**

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

G. Ford and N. E. Gibbs, ***A Mature Profession of Software Engineering***, Software Engineering Institute, Carnegie Mellon University, Pittsburgh, Pennsylvania, Technical CMU/SEI-96-TR-004, January 1996.

Professional Development



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**:

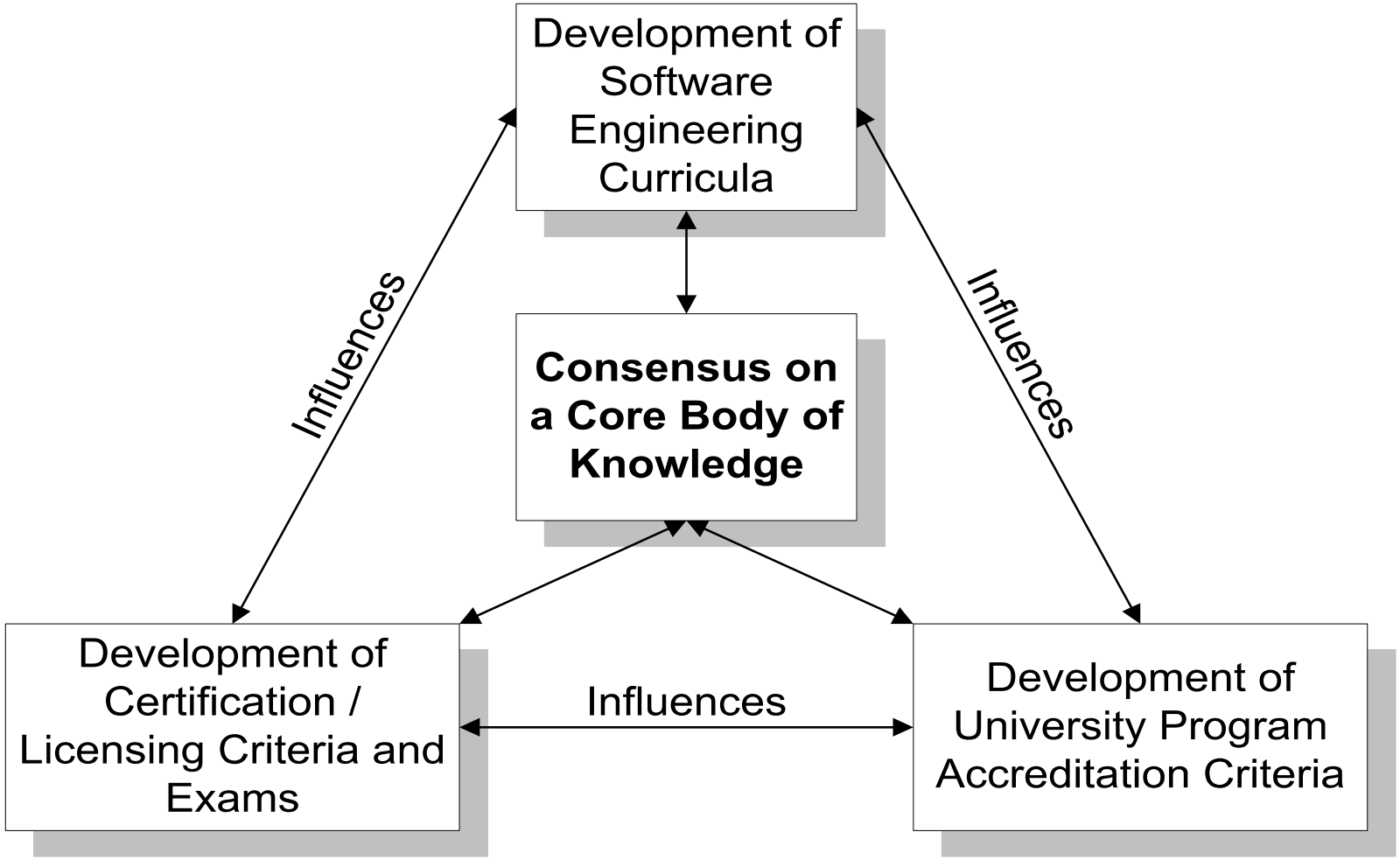
- Develops expertise internally
- Develops internal system knowledge:
  - Procedural know-how & technologies
- Take years to train staff
- Keeps specialized knowledge as **trade secrets** for competitive edge

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



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

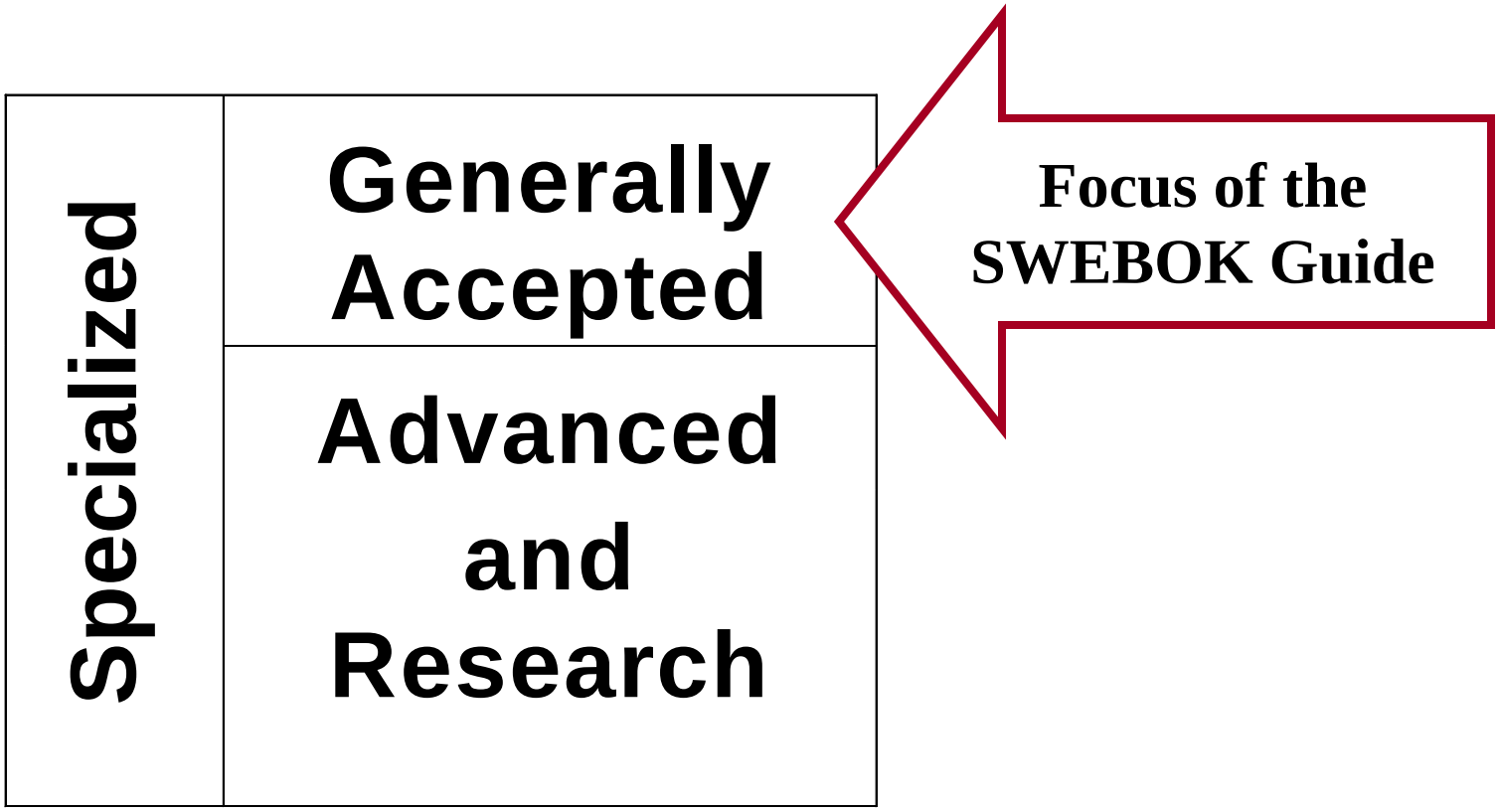
What is Software Engineering?

- IEEE Std 610.12:

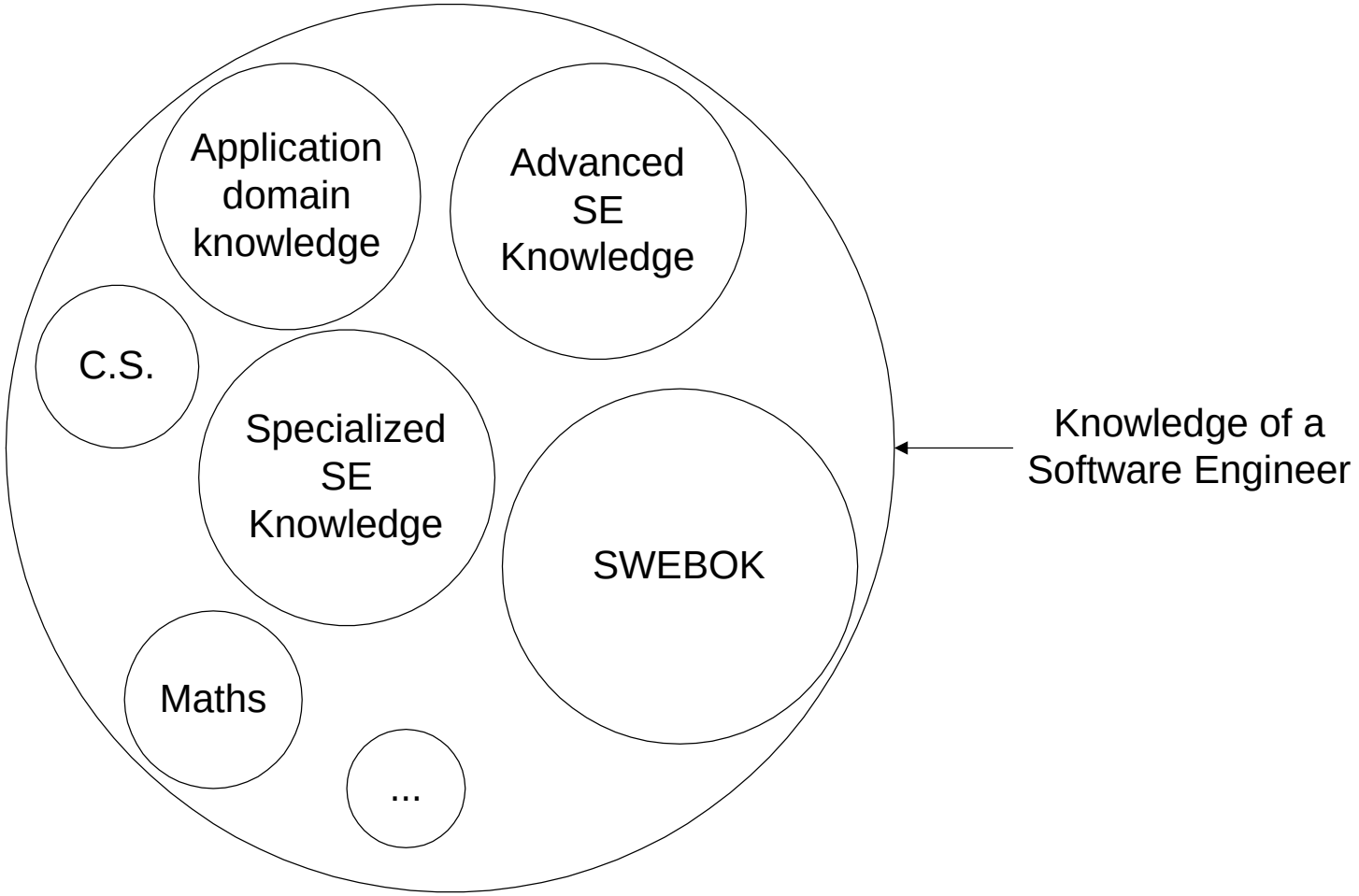
  (1) The application of a **systematic**, **disciplined**, **quantifiable** approach to the development, operation, and maintenance of software; that is, the application of engineering to software.

  (2) The study of approaches as in (1).

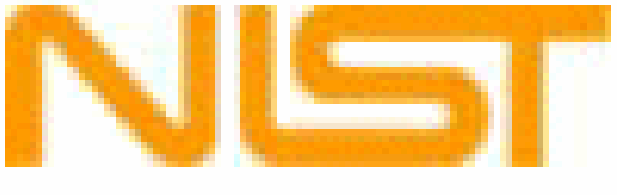
Categories of Knowledge in the SWEBOK



Software Engineer's Knowledge

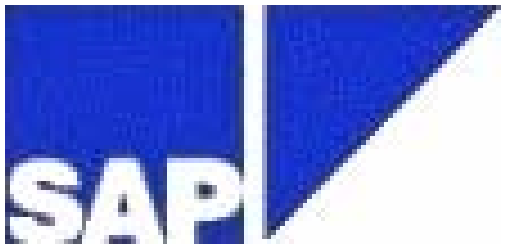


Corporate Support by:



National Research Council Canada

Conseil national de recherches Canada



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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Guide Editors

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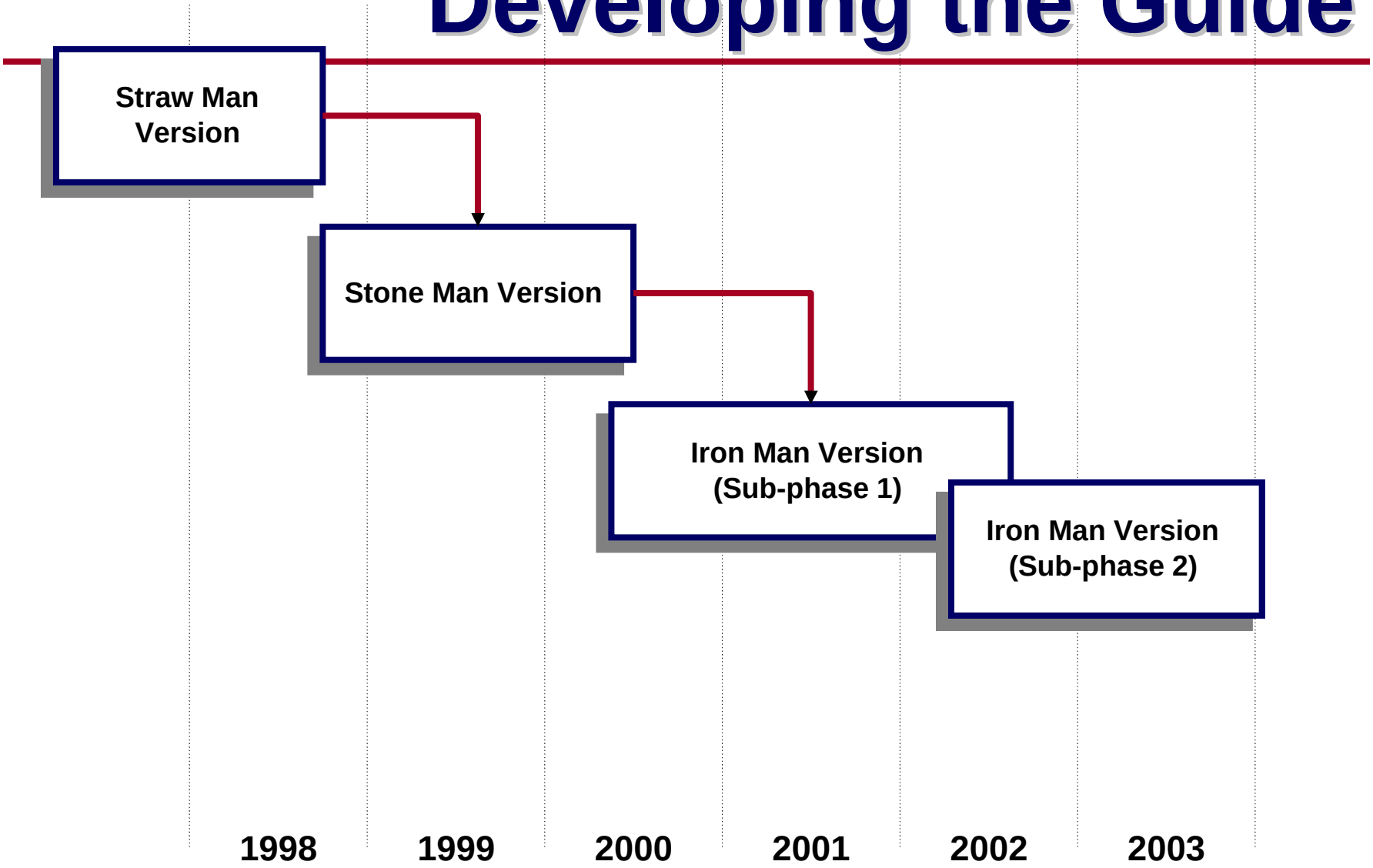
Université du Québec à Montréal

A Three-Phase Approach for Developing the Guide



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

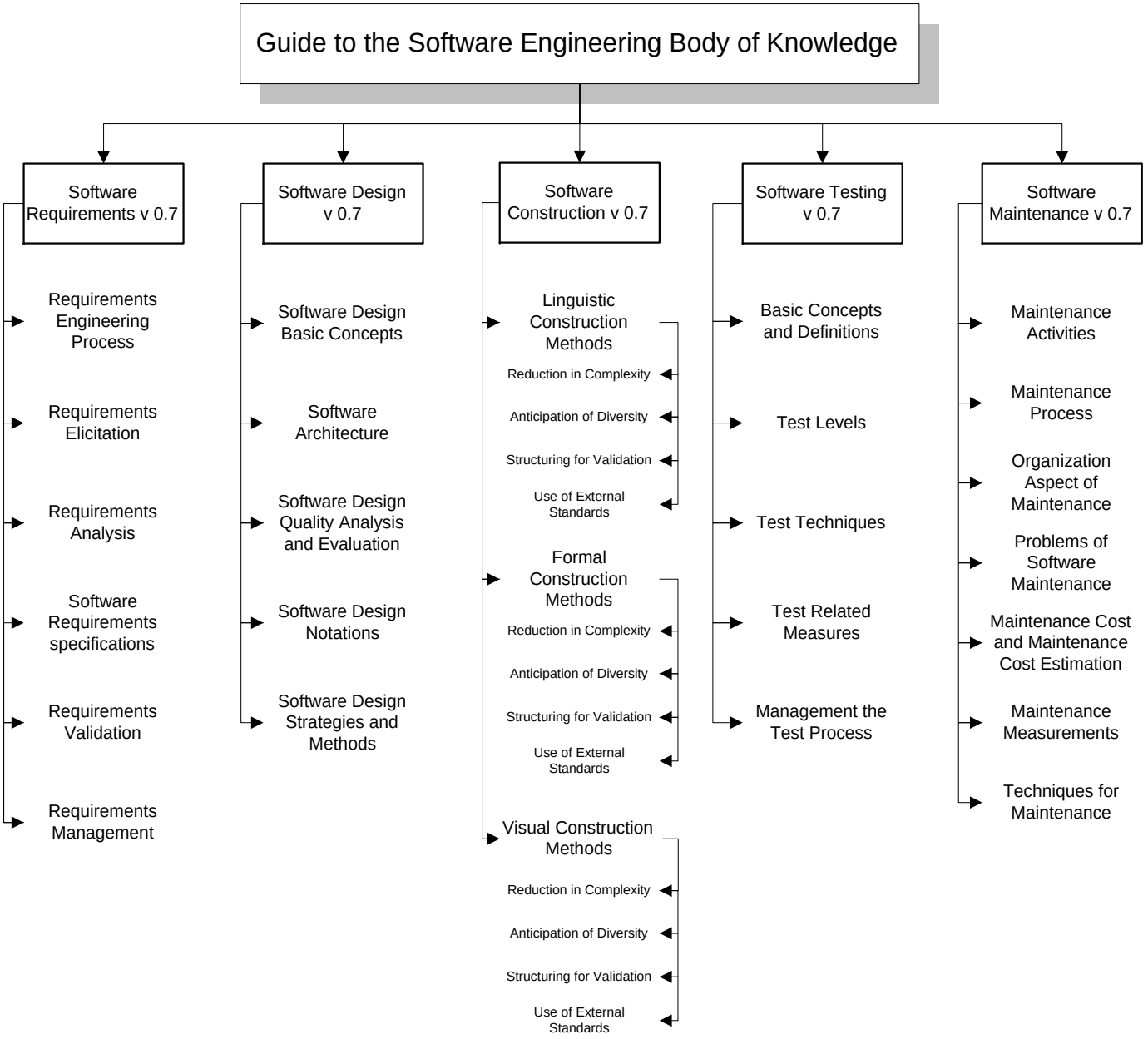
- *Consensus* on a list of Knowledge Areas
- *Consensus* on a list of topics and relevant reference materials for each Knowledge Area
- *Consensus* on a list of Related Disciplines
- Available free on the web

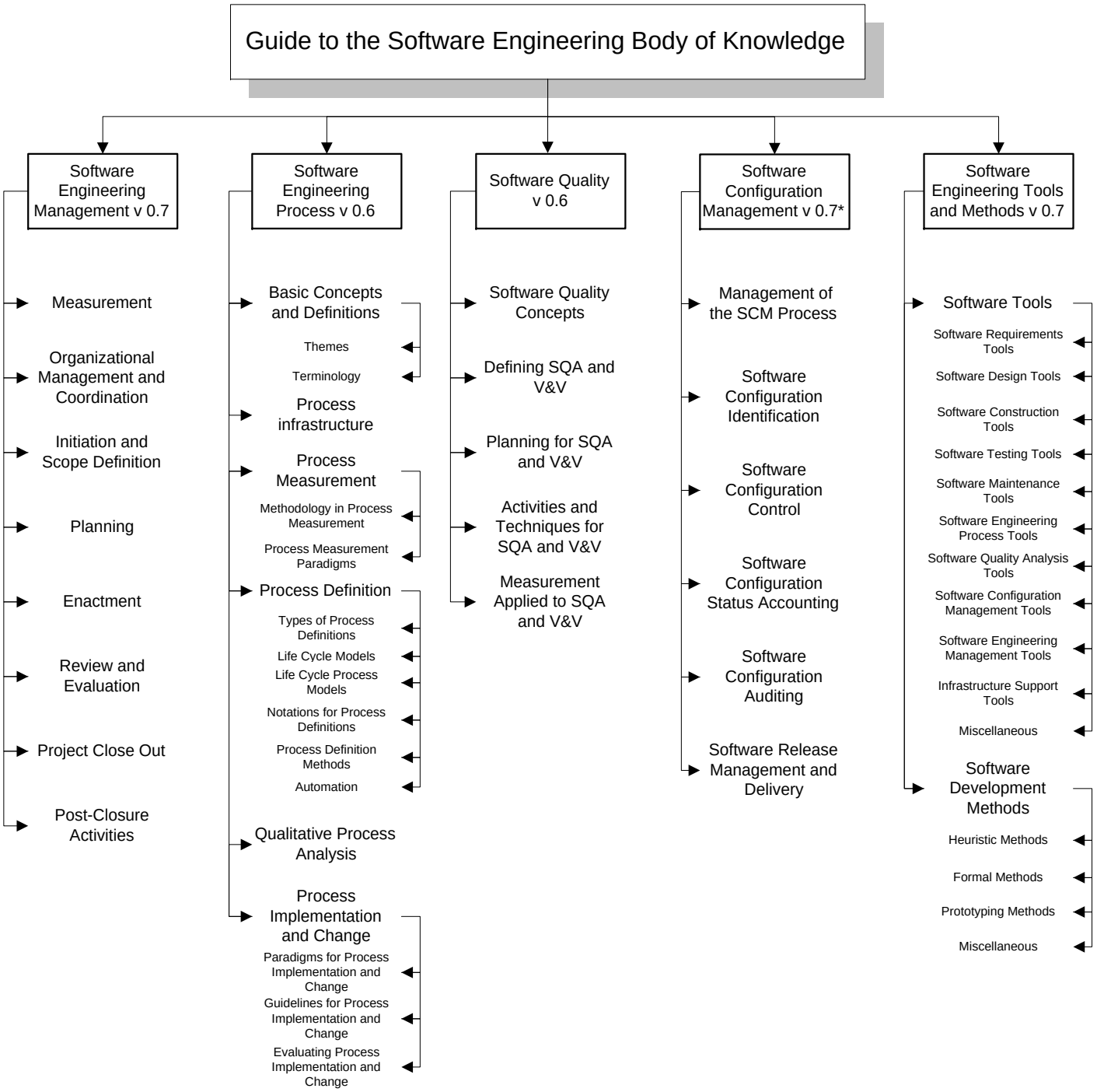
Baseline List of Knowledge Areas

- 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


Guide to the Software Engineering Body of Knowledge
Software Requirements v 0.7
Requirements Engineering Process
Requirements Elicitation
Requirements Analysis
Software Requirements specifications
Requirements Validation
Requirements Management
Software Design v 0.7
Software Design Basic Concepts
Software Architecture
Software Design Quality Analysis and Evaluation
Software Design Notations
Software Design Strategies and Methods
Software Construction v 0.7
Linguistic Construction Methods
Reduction in Complexity
Anticipation of Diversity
Structuring for Validation
Use of External Standards
Formal Construction Methods
Reduction in Complexity
Anticipation of Diversity
Structuring for Validation
Use of External Standards
Visual Construction Methods
Reduction in Complexity
Anticipation of Diversity
Structuring for Validation
Use of External Standards
Software Testing v 0.7
Basic Concepts and Definitions
Test Levels
Test Techniques
Test Related Measures
Management the Test Process
Software Maintenance v 0.7
Maintenance Activities
Maintenance Process
Organization Aspect of Maintenance
Problems of Software Maintenance
Maintenance Cost and Maintenance Cost Estimation
Maintenance Measurements
Techniques for Maintenance


Guide to the Software Engineering Body of Knowledge
Software Engineering Management v 0.7
Measurement
Organizational Management and Coordination
Initiation and Scope Definition
Planning
Enactment
Review and Evaluation
Project Close Out
Post-Closure Activities
Software Engineering Process v 0.6
Basic Concepts and Definitions
Themes
Terminology
Process infrastructure
Process Measurement
Methodology in Process Measurement
Process Measurement Paradigms
Process Definition
Types of Process Definitions
Life Cycle Models
Life Cycle Process Models
Notations for Process Definitions
Process Definition Methods
Automation
Qualitative Process Analysis
Process Implementation and Change
Paradigms for Process Implementation and Change
Guidelines for Process Implementation and Change
Evaluating Process Implementation and Change
Software Quality v 0.6
Software Quality Concepts
Defining SQA and V&V
Planning for SQA and V&V
Activities and Techniques for SQA and V&V
Measurement Applied to SQA and V&V
Software Configuration Management v 0.7*
Management of the SCM Process
Software Configuration Identification
Software Configuration Control
Software Configuration Status Accounting
Software Configuration Auditing
Software Release Management and Delivery
Software Engineering Tools and Methods v 0.7
Software Tools
Software Requirements Tools
Software Design Tools
Software Construction Tools
Software Testing Tools
Software Maintenance Tools
Software Engineering Process Tools
Software Quality Analysis Tools
Software Configuration Management Tools
Software Engineering Management Tools
Infrastructure Support Tools
Miscellaneous
Software Development Methods
Heuristic Methods
Formal Methods
Prototyping Methods
Miscellaneous

SWEBOK Body of Knowledge

- 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?

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Engineering Discipline?

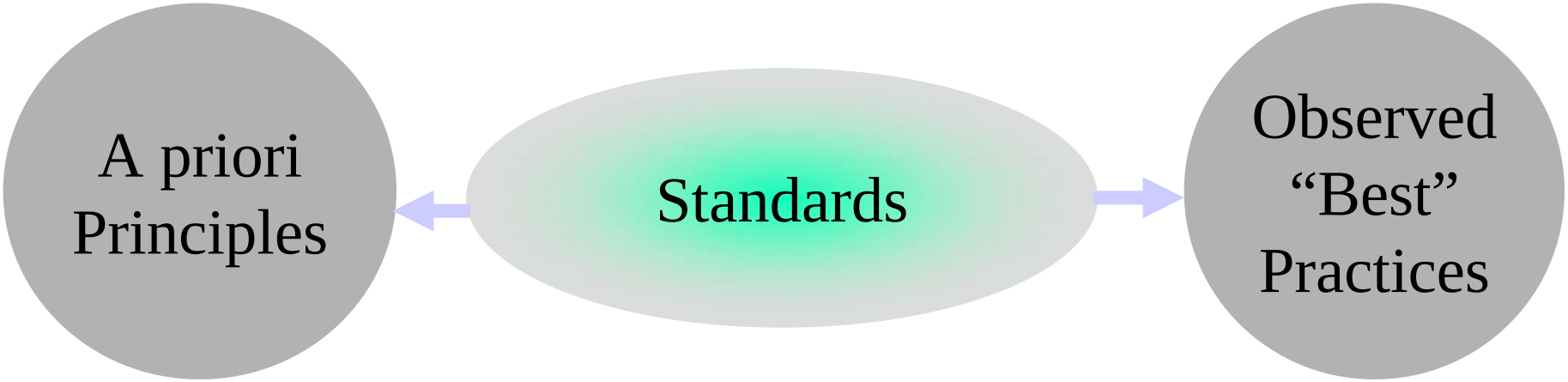
Fundamental Principles of Software Engineering

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.

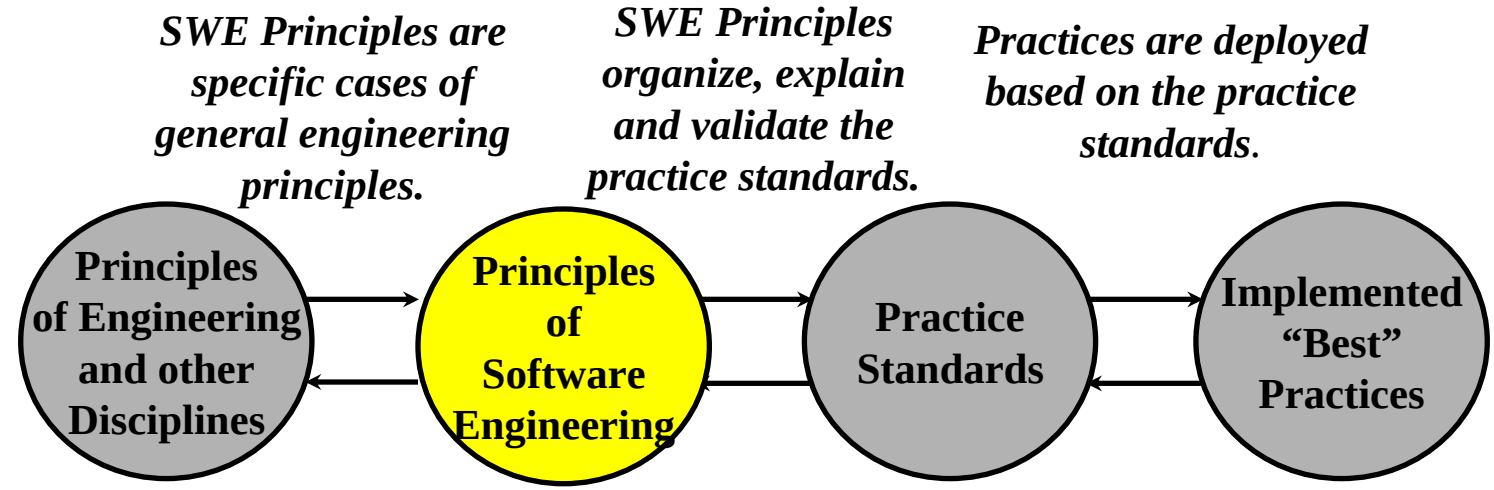
L1

L1 We have to invent 'what'?

LOG, 8/20/2007

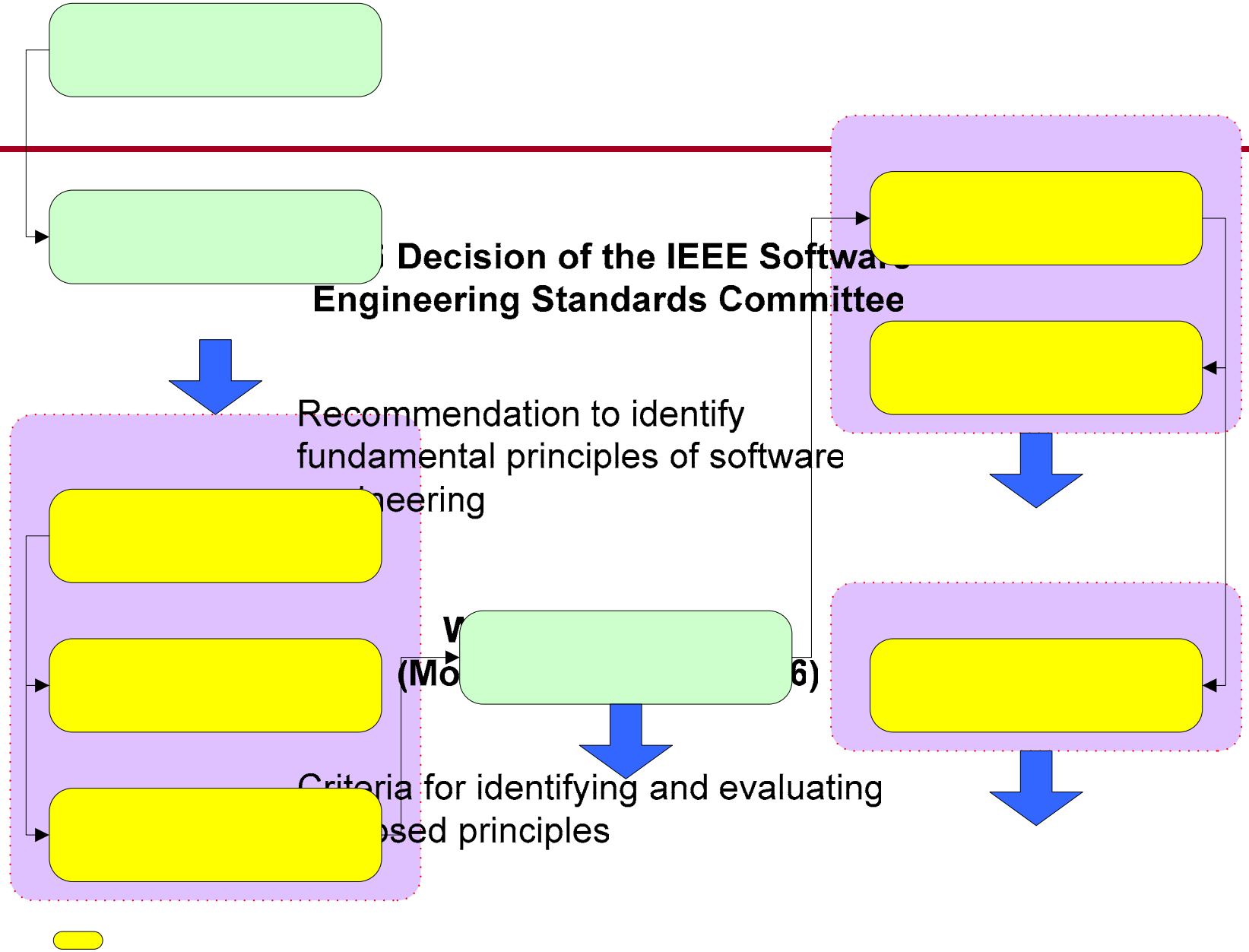
Fundamental Principles of Software Engineering

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



Source: [Jabir97]

1996-1998 Delphi Studies



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

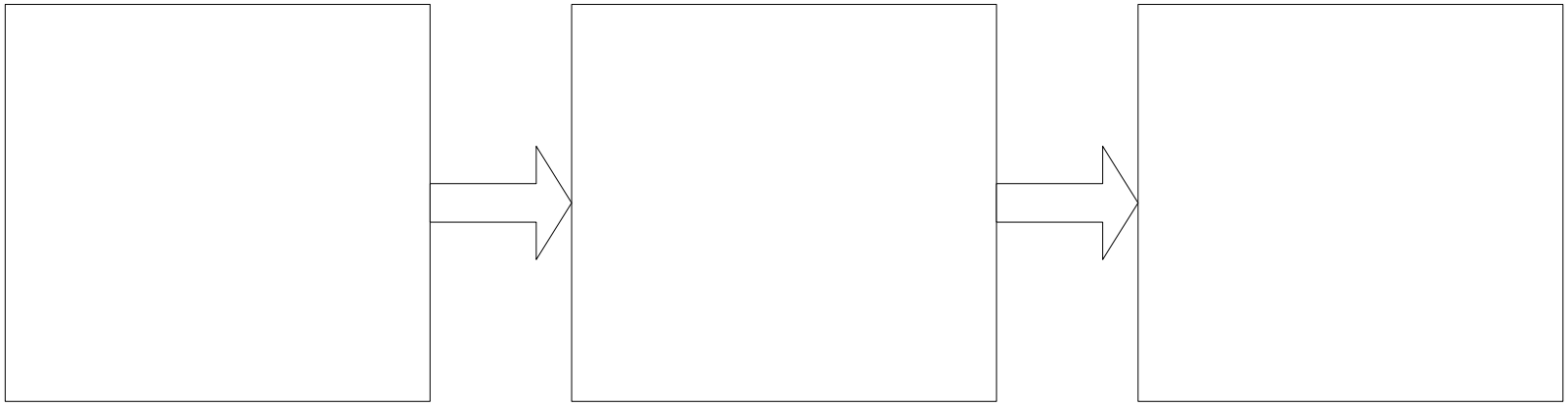
L2 Est-ce le bon mot en anglais?

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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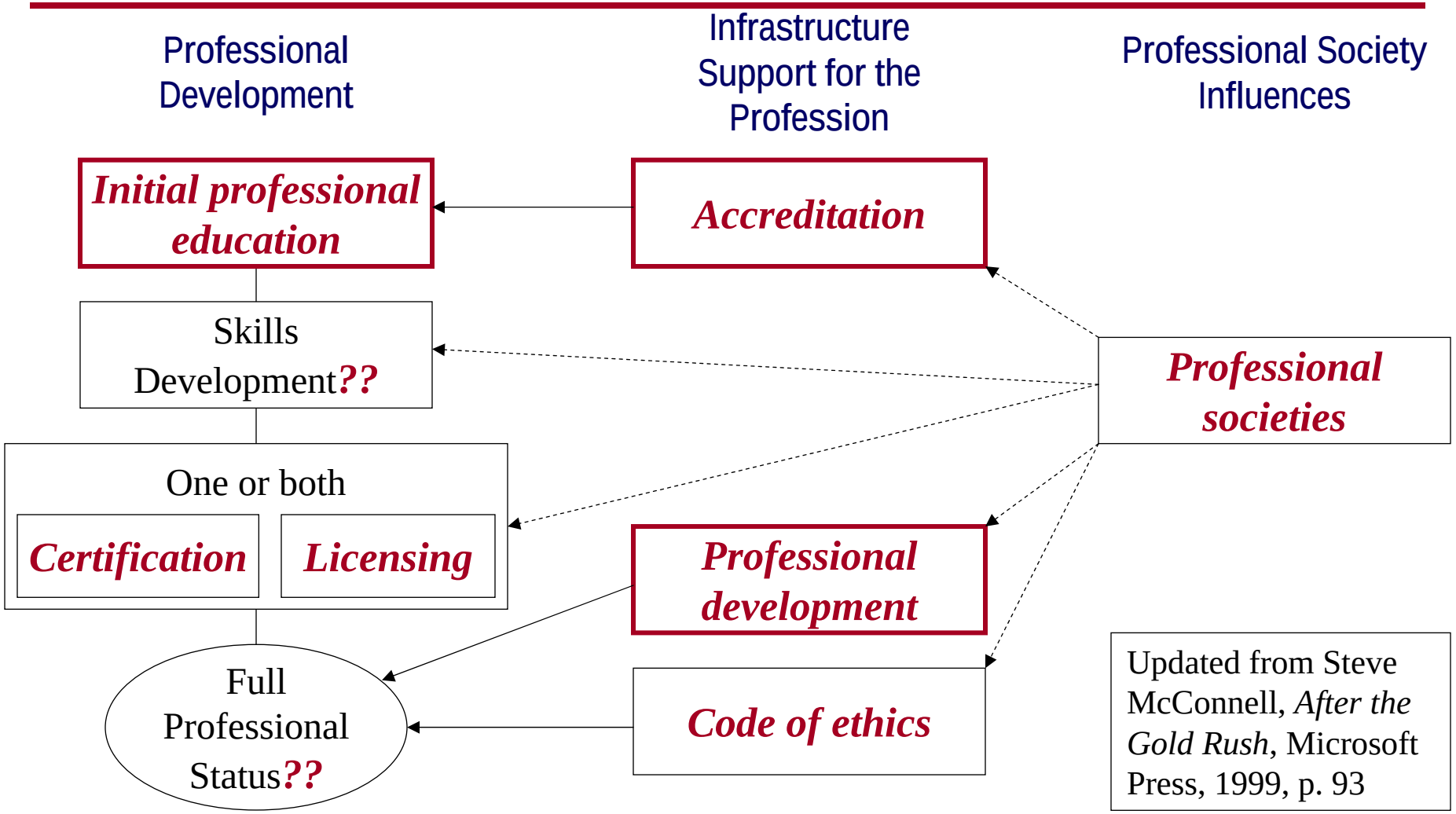
Software Engineering Today



New Engineering Disciplines

Knowledge Engineering disciplines:

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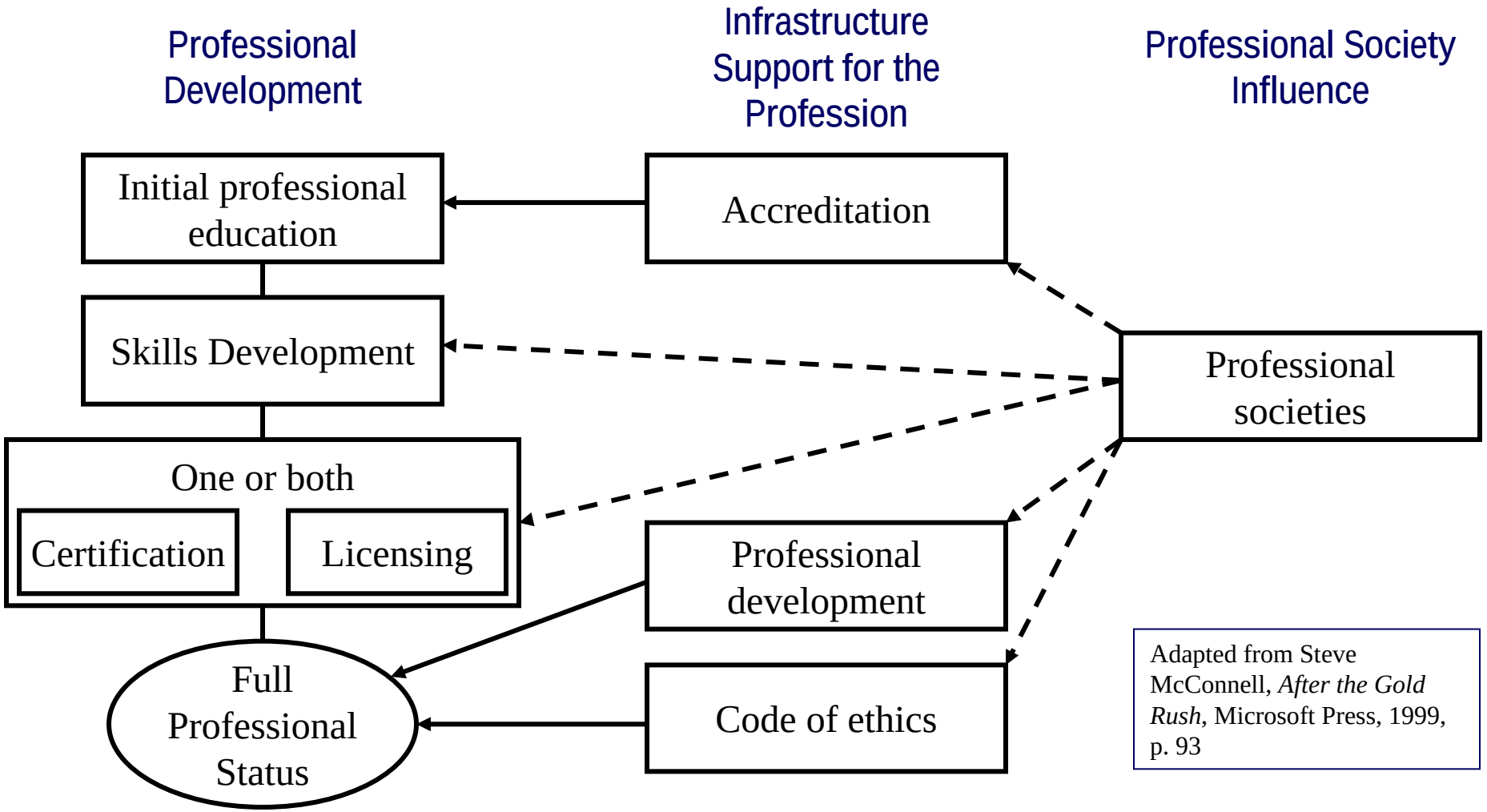
- Knowledge Engineering
- Web engineering
- Systems Engineering
- Value Engineering
- Systems Engineering
- Information Technology

Other New Engineering Disciplines: How do they stack up today?



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www.swebok.org

www.gelog.etsmtl.ca

Questions

Acknowledgements

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- Pierre Bourque
- Robert Dupuis
- Leonard Tripp
- James W. Moore