Professionalizing the Practice of Software Engineering

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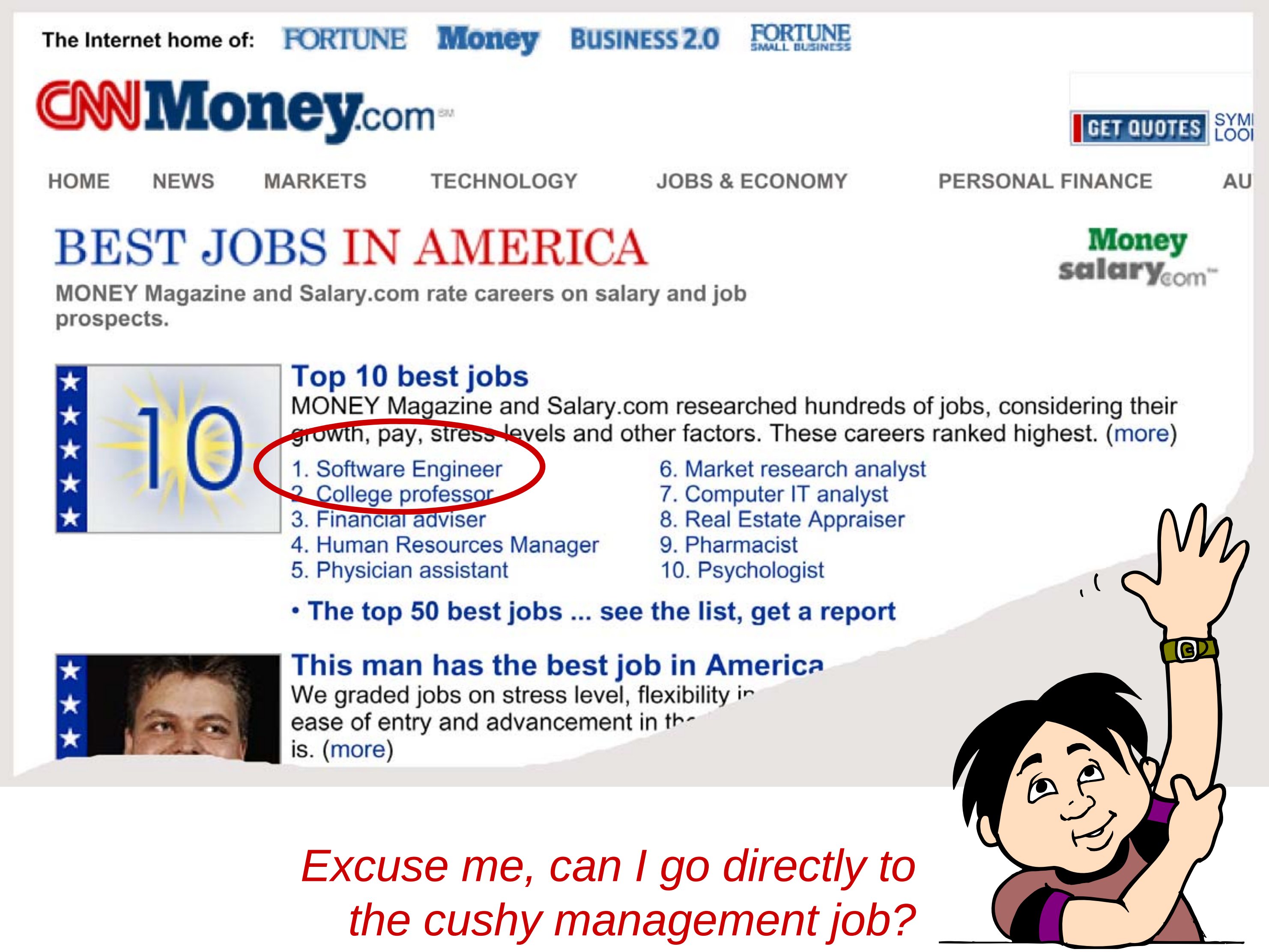
James W. Moore, CSDP, F-IEEE

The MITRE Corporation

May 2008

Software Engineer: Best Job in America?



The Internet home of: FORTUNE Money BUSINESS 2.0 FORTUNE SMALL BUSINESS

CNNMoney.com

HOME NEWS MARKETS TECHNOLOGY JOBS & ECONOMY PERSONAL FINANCE AU

BEST JOBS IN AMERICA

Money salary.com

MONEY Magazine and Salary.com rate careers on salary and job prospects.

Top 10 best jobs

MONEY Magazine and Salary.com researched hundreds of jobs, considering their growth, pay, stress levels and other factors. These careers ranked highest. (more)

1. Software Engineer
2. College professor
3. Financial adviser
4. Human Resources Manager
5. Physician assistant
6. Market research analyst
7. Computer IT analyst
8. Real Estate Appraiser
9. Pharmacist
10. Psychologist

- **The top 50 best jobs ... see the list, get a report**

This man has the best job in America

We graded jobs on stress level, flexibility in ease of entry and advancement in th is. (more)

Excuse me, can I go directly to the cushy management job?

"**Why it's great:** Software engineers are needed in virtually every part of the economy, making this one of the fastest-growing job titles in the U.S. Even so, it's not for everybody.

Designing, developing and testing computer programs requires some pretty advanced math skills and creative problem-solving ability. If you've got them, though, you can work and live where you want: Telecommuting is quickly becoming widespread.

The profession skews young – the up-all-night-coding thing gets tired – but consulting and management positions aren't hard to come by once you're experienced."

CNNMoney.com, "Best Jobs in America," http://money.cnn.com/magazines/moneymag/bestjobs/?cnn=yes, viewed 12 April 2006

So What is a Software Engineer?

- Is it simply coding?

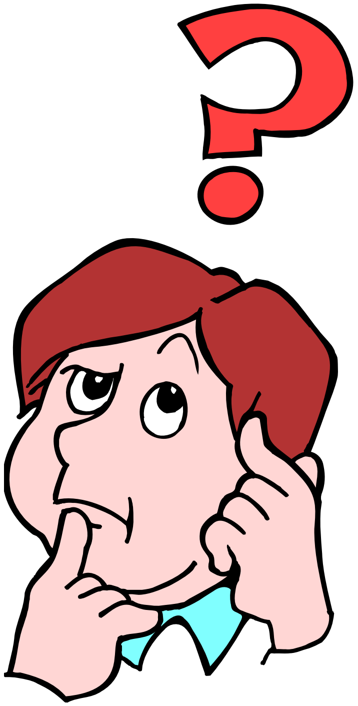
Computer systems software engineers *primarily write, modify, test, and develop software to meet the needs of a particular customer. They develop software systems for control and automation in manufacturing, business, and other areas.*

U.S. Department of Labor

Bureau of Labor Statistics

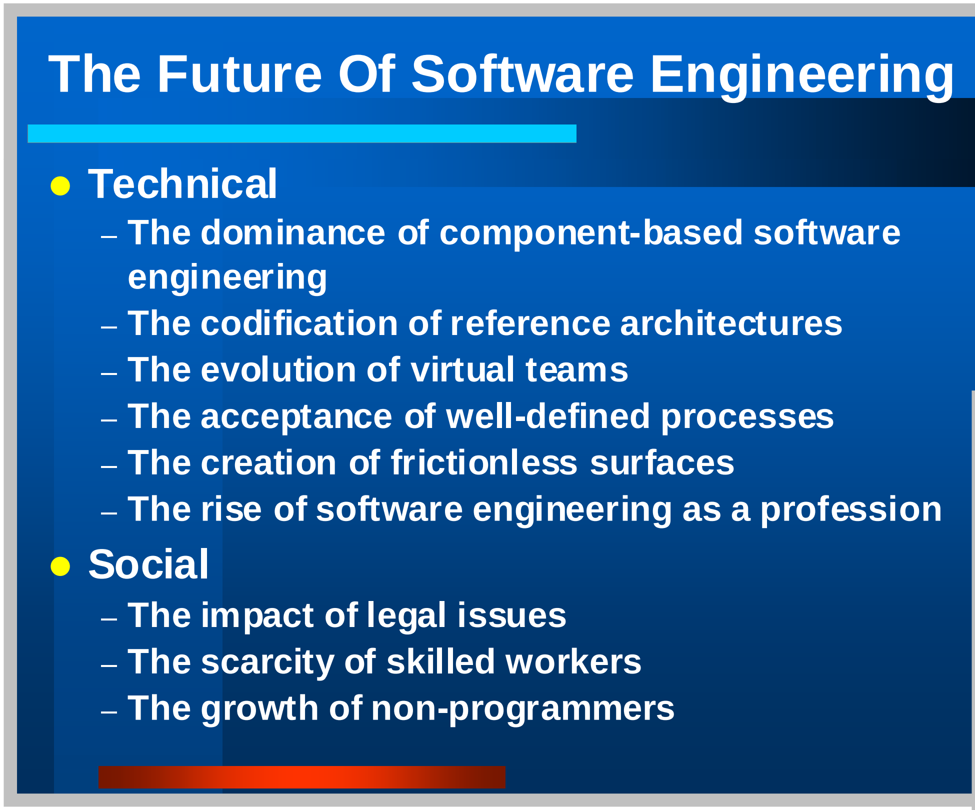
Occupational Outlook Handbook

www.bls.gov



Hmmm ... Not very specific! How can I determine if someone is competent to do this?

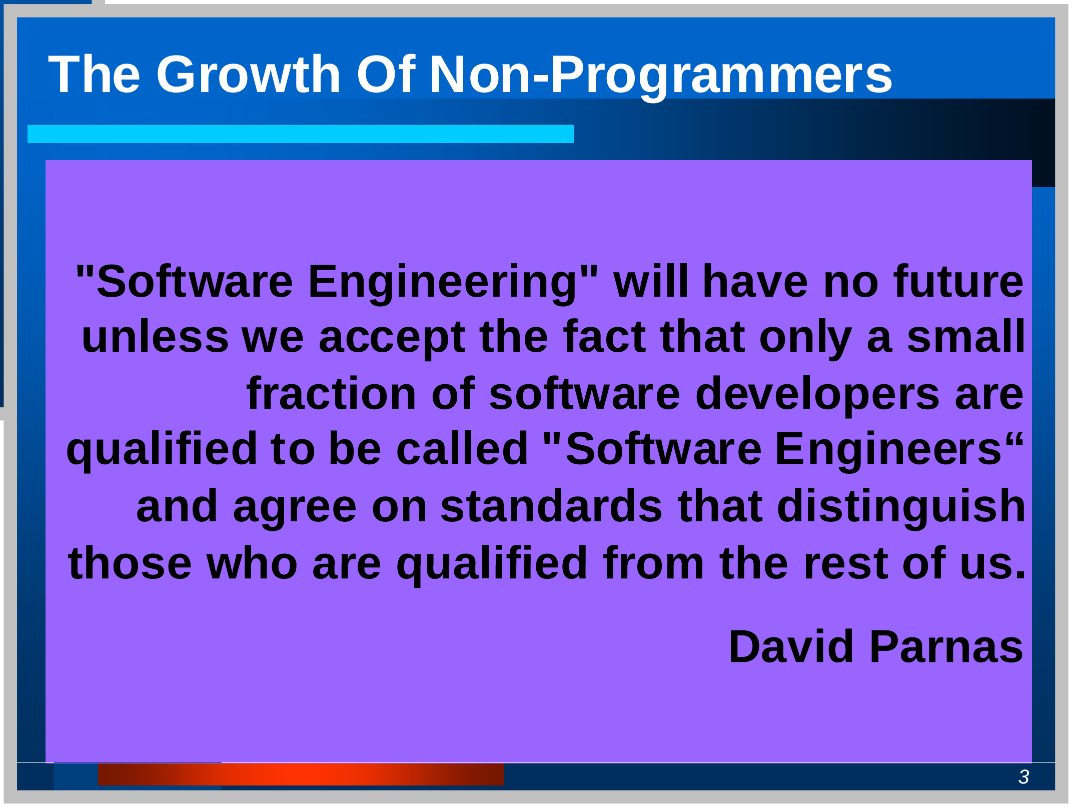
Software Engineering is a Profession



The Future Of Software Engineering

- Technical
  - The dominance of component-based software engineering
  - The codification of reference architectures
  - The evolution of virtual teams
  - The acceptance of well-defined processes
  - The creation of frictionless surfaces
  - The rise of software engineering as a profession
- Social
  - The impact of legal issues
  - The scarcity of skilled workers
  - The growth of non-programmers

From Grady Booch, “The Future of Software”



The Growth Of Non-Programmers

"Software Engineering" will have no future unless we accept the fact that only a small fraction of software developers are qualified to be called "Software Engineers“ and agree on standards that distinguish those who are qualified from the rest of us.

David Parnas

3

Programmer vs Software Engineer

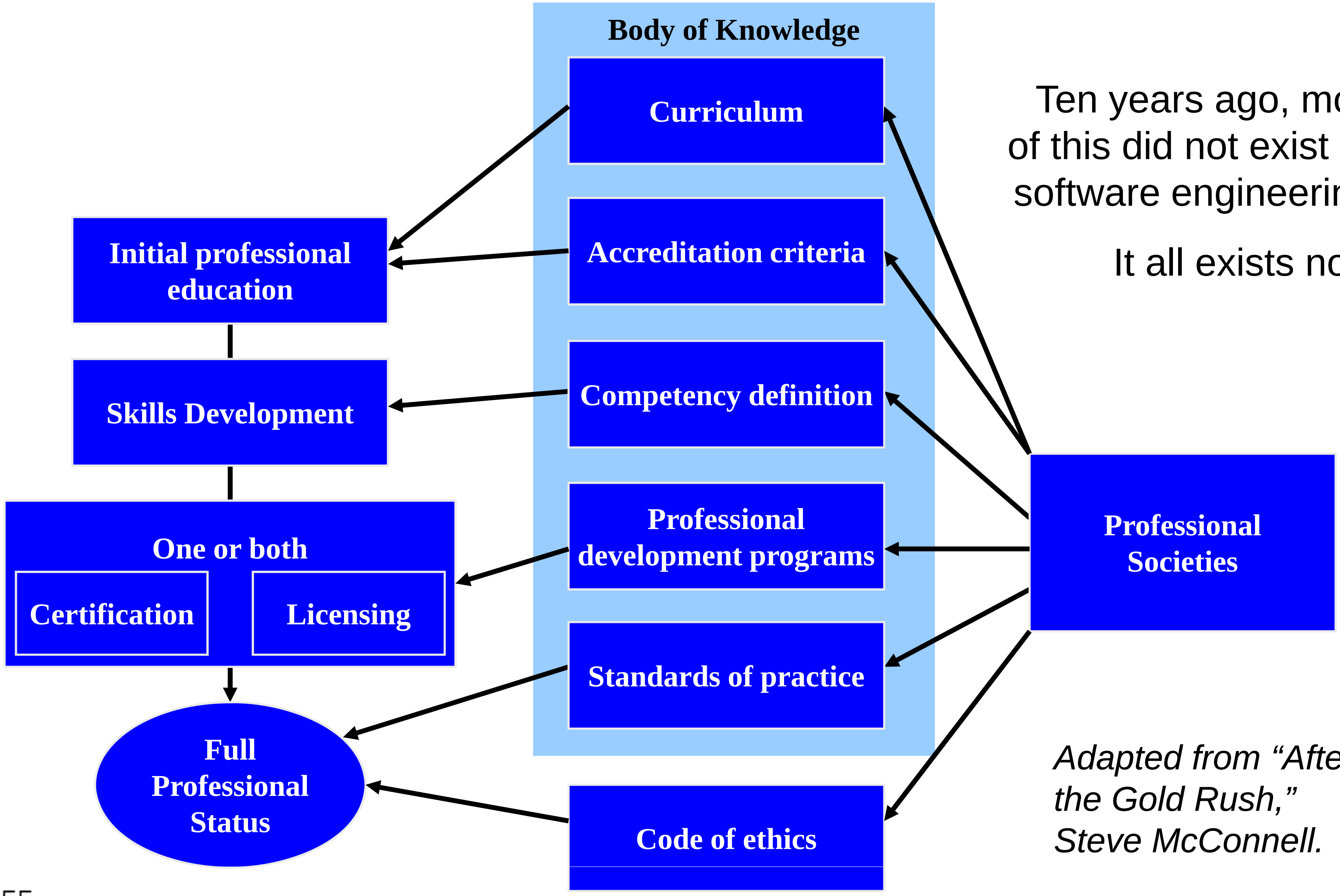
Programmer	***Software Engineer***
Writing *code*	Developing *systems*, often large and highly complex
Using techniques learned from individual *experience*	Applying widely accepted techniques based on *proven knowledge*
Building products that *work*	Building products that *you can depend on*

Model of the Maturity of a Profession

- 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.

A Model of a Profession



Body of Knowledge

Curriculum

Accreditation criteria

Competency definition

Professional development programs

Standards of practice

Code of ethics

Initial professional education

Skills Development

One or both

Certification

Licensing

Full Professional Status

Professional Societies

Ten years ago, most of this did not exist for software engineering.

It all exists now.

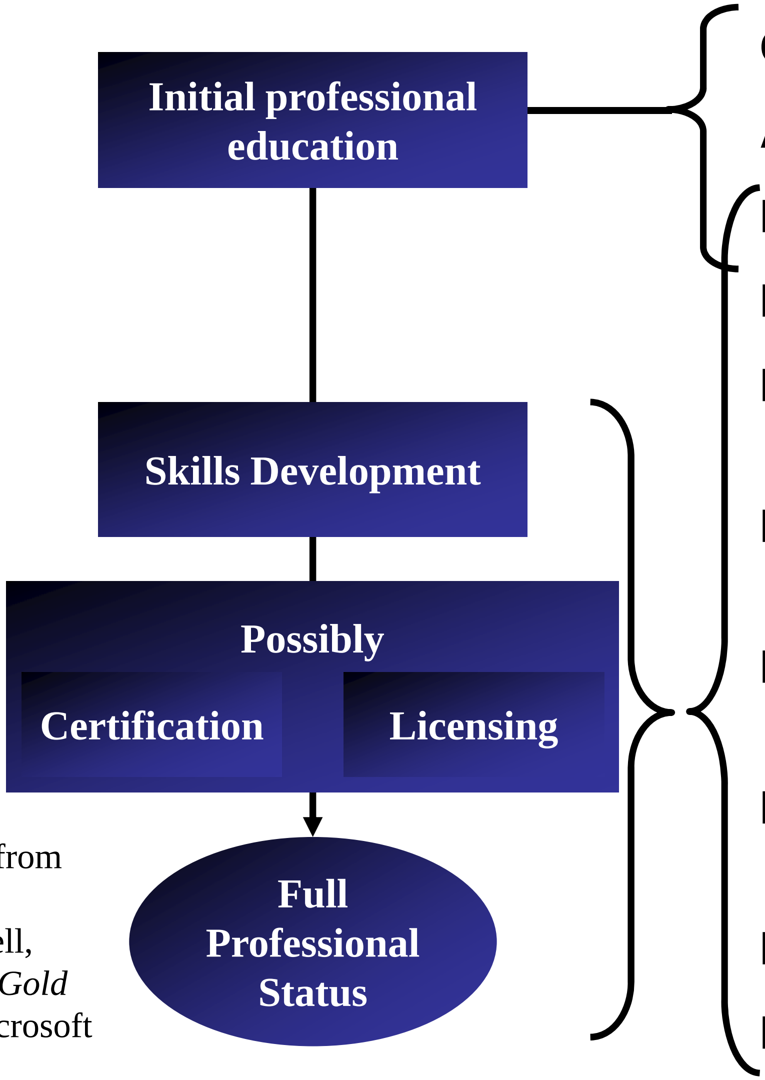
Adapted from "After the Gold Rush," Steve McConnell.

SW Engineering is Achieving Recognition as an Engineering Profession

- ***Licensing*** for software engineers is underway in Texas, British Columbia, Ontario, Canada and other countries.
- One can now get a ***degree in software engineering***. There are now 32 bachelor's level degree programs (15 accredited), 53 master's, and 4 PhD programs in the US. (As of Oct 2005.) Another 15 accredited bachelor's programs in Canada.
  - There is now a mechanism for ***accreditation of university curricula*** in software engineering.
  - IEEE-CS/ACM ***Software Engineering Curriculum*** 2004 is published.
- IEEE-CS Guide to the Software Engineering ***Body of Knowledge***, 2004 Version is published in book form and on the web. Translations to other languages are available.
- ACM/IEEE-CS Software Engineering ***Code of Ethics*** was completed in 1998.

IEEE CS Support of the Professional

Professional Development



Initial professional education

Skills Development

Possibly

Certification

Licensing

Full Professional Status

Adapted from Steve McConnell, *After the Gold Rush*, Microsoft Press

Necessary Infrastructure Support	Example Products and Services of Professional Societies
Curricula	**SE 2004**
Accreditation	**ABET/CSAB**
Body of knowledge	***SWEBOK Guide***
Prof. literature	**IT Pro, Software**
Prof. interaction	**Chapters,** **Elec. Communities**
Prof. training	**DVP, Tutorials,** **Distance Learning**
Design solutions	***Standards,*** **Workshops**
Practice norms	***Standards*, ** **Best Practices**
Ethical norms	***Code of Ethics***
Prof. certification	***CSDA, CSDP***

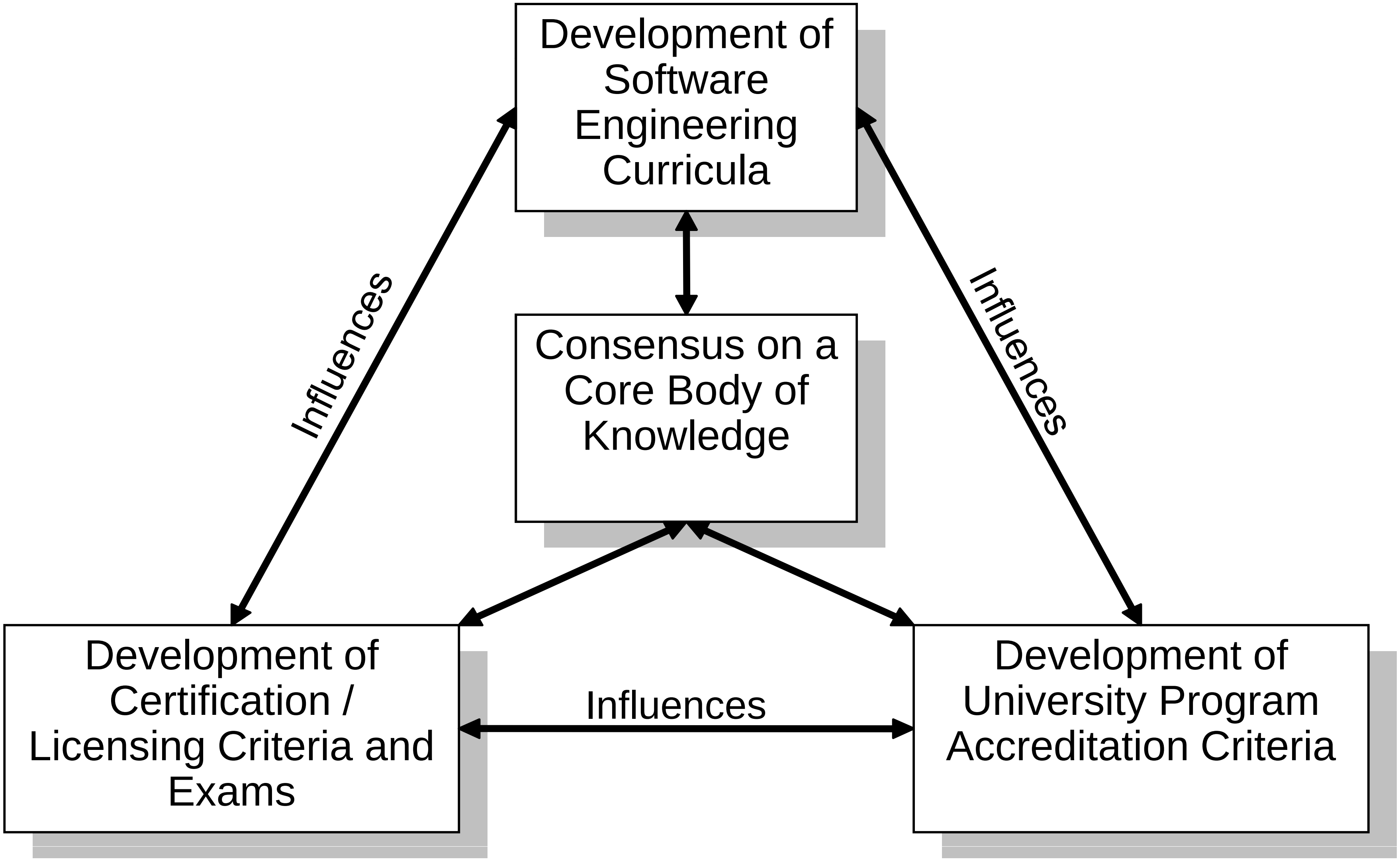
Guide to the Software Engineering Body of Knowledge

Software Engineering Body of Knowledge Project

- 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 - SWEBOK
- ***Provide a topical access*** to the SWEBOK
- ***Provide a foundation*** for curriculum development and individual certification and licensing material

The Body of Knowledge for software engineering already exists in the literature. The mission of the SWEBOK project is to provide an authoritative guide to the portion that is "generally accepted."

Key Interrelationships for a Core Body of Knowledge


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
Influences
Influences
Influences

Project Organization

Editorial team

- Project “Champion”:
  - Leonard Tripp, 1999 President, IEEE Computer Society
- Executive Editors:
  - Alain Abran, École de Technologie Supérieure
  - James W. Moore, The MITRE Corp.
- Editors:
  - Pierre Bourque, École de Technologie Supérieure
  - Robert Dupuis, UQAM

Industrial Advisory Board

- Provided funding for free availability.
- Provided practical advice
- Provided early feedback

Knowledge Area Specialists

- Pete Sawyer & Gerald Kotonia, UK
- Guy Tremblay, Canada
- Steve McConnell & Terry Bollinger, USA, Louis Martin & Philippe Gabrini, Canada
- Antonia Bertolino & Eda Marchetti, Italy
- Tom Pigoski, USA, Alain April, Canada
- John Scott & David Nisse, USA
- Stephen MacDonnell & Andrew Gray, New Zealand, Dennis Frailey, USA
- Khaled El Emam, Canada
- David Carrington, Australia
- Dolores Wallace & Larry Reeker, USA, Alain April, Canada

Reviewers

- Three review cycles
- Approximately 500 reviewers, 42 countries
- Approximately 10,000 comments

SWEBOK Industrial Advisory Board

Corporate Support by:

BOEING®

Canadian Council of Professional Engineers
Conseil canadien des ingénieurs

Construx
SOFTWARE

MITRE

NIST

National Research Council Canada

Conseil national de recherches Canada

Rational®
the e-development company™

Raytheon

SAP™

Project managed by:

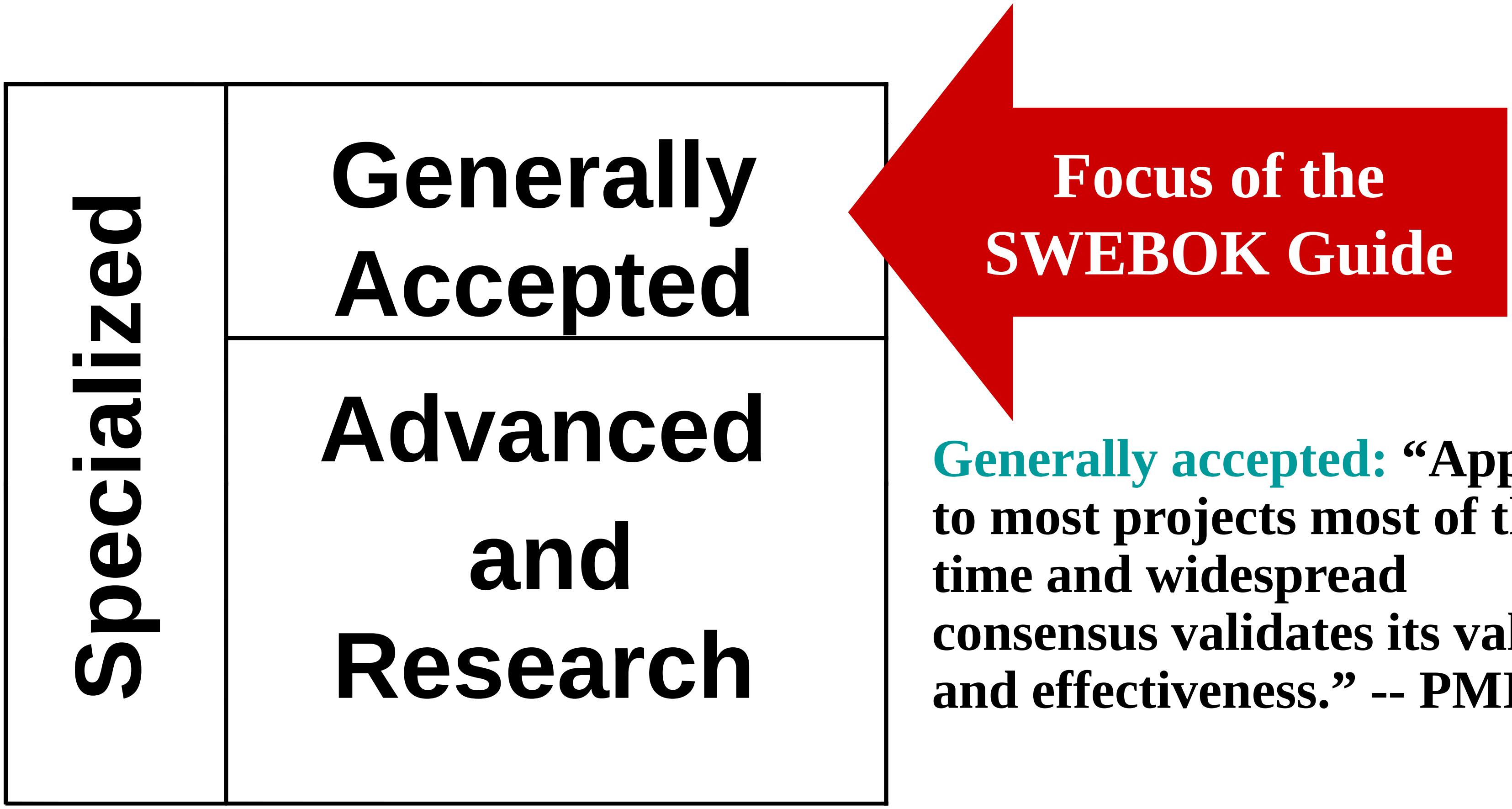
Université du Québec
École
de technologie
supérieure

UQÀM

Reviewer Demographics

- Four rounds of review and comment disposition, using a variety of populations
- A total of about 10,000 comments
- Nearly 600 individual reviewers
  - About half were non-US
  - Roughly equal split: BS, MS, PhD
  - Roughly equal split: 0-50 employees, 50-500, 500+

Types of Knowledge



Generally accepted: **“Applies to most projects most of the time and widespread consensus validates its value and effectiveness.” -- PMI**

In terms of US education, we target the SWEBOK at bachelor’s degree plus four years of experience.

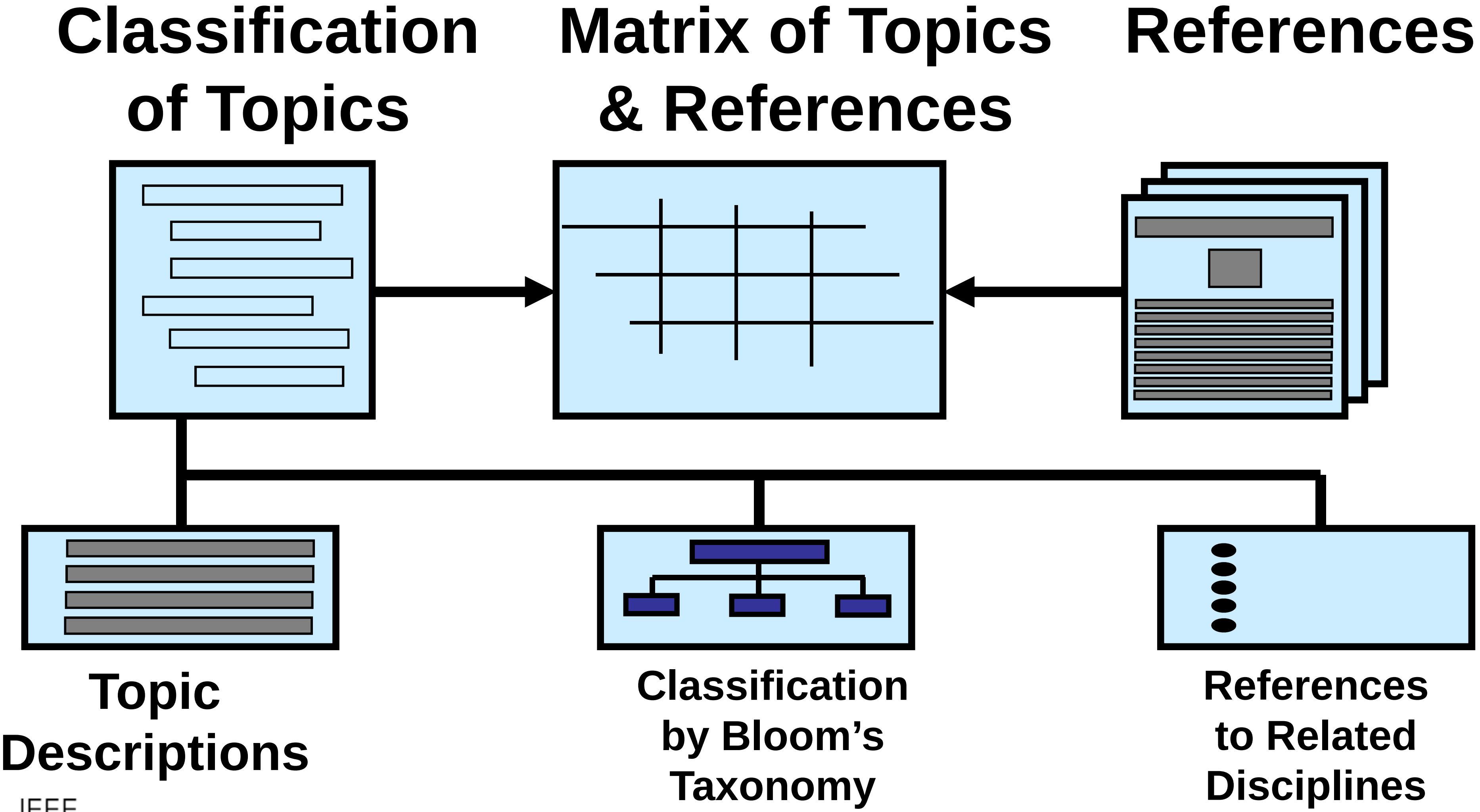
Ten Knowledge Areas

- **Software Requirements**
- **Software Design**
- **Software Construction**
- **Software Testing**
- **Software Maintenance**
- **Software Configuration Management**
- **Software Eng. Management**
- **Software Eng. Tools & Methods**
- **Software Engineering Process**
- **Software Quality**

Related Disciplines

- Computer Science
- Mathematics
- Project Management
- Computer Engineering
- Cognitive Sciences
- Human Factors
- Systems Engineering
- Management
- Management Science

Knowledge Area Description



Classification of Topics

Matrix of Topics & References

References

Topic Descriptions

Classification by Bloom's Taxonomy

References to Related Disciplines

Examples of SWEBOK Uptake

- Available for free on the web (http://www.swebok.org) and in book form
- Translated (or translating) into Japanese, Chinese, Spanish, French, Russian, Hungarian, Arabic
- CSDA, CSDP, and SE2004 cite SWEBOK Guide as a source
- SWEBOK Guide was adopted as ISO/IEC TR 19759
- A large defense contractor has experimented with the Guide to calibrate skills descriptions in proposals.
- An FFRDC has rewritten its “Software Systems Engineer” job description in terms of the SWEBOK knowledge areas.
- Construx, Inc. has rewritten its position descriptions in terms of the Guide, structures its professional development around the Guide.
- NTU and SMU have rationalized their software engineering offerings using the SWEBOK.
- SWEBOK provides the taxonomical basis for VISEK, a SWE Portal funded by the German government.
- SWEBOK contributed to “SW Development” portion of a BOK developed by the Canadian Council of Professional Engineers for use in provincial licensing programs.
- SWEBOK influenced the IFIP committee on IT professionalism.
- 155,000 Google hits on “SWEBOK” in May 2007

Software Engineering Standards

A standard is a name for an otherwise fuzzy concept

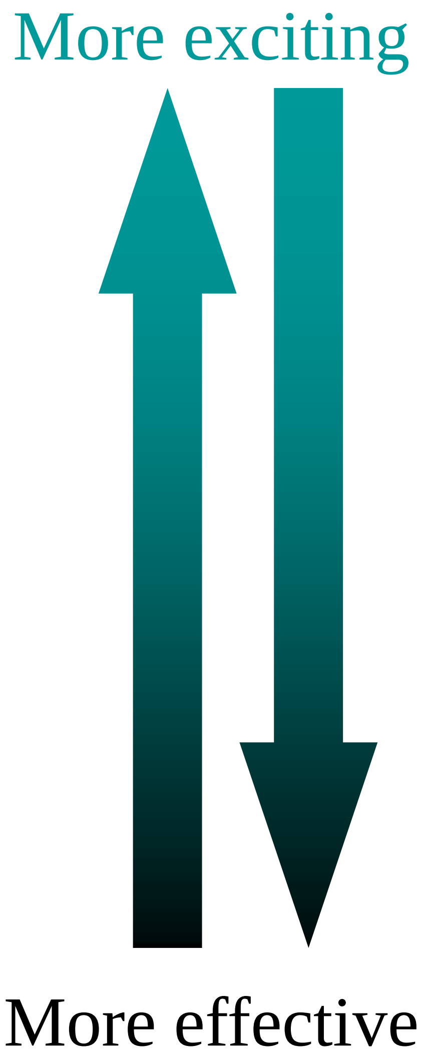
In a complex, multidimensional trade space of solutions …

… a standard gives a name to a bounded region.

It defines some characteristics that a buyer can count on.

Roles of Software Engineering Standards

- Specify techniques to develop software faster, cheaper, better, IEEE 982.1 (Measures for Reliable SW)
- Provide consensus validity for "best practices" that cannot be scientifically validated, IEEE 1008 (Unit Testing)
- Provide uniformity in cases where agreement is more important than small improvements, IEEE 1320.1 (IDEF0)
- Provide a framework for communication between buyer and seller, ISO/IEC/IEEE 12207 (SW Life Cycle Processes)
- Give precise names to concepts that are fuzzy, complex, detailed and multidimensional, IEEE 1028 (SW Reviews)

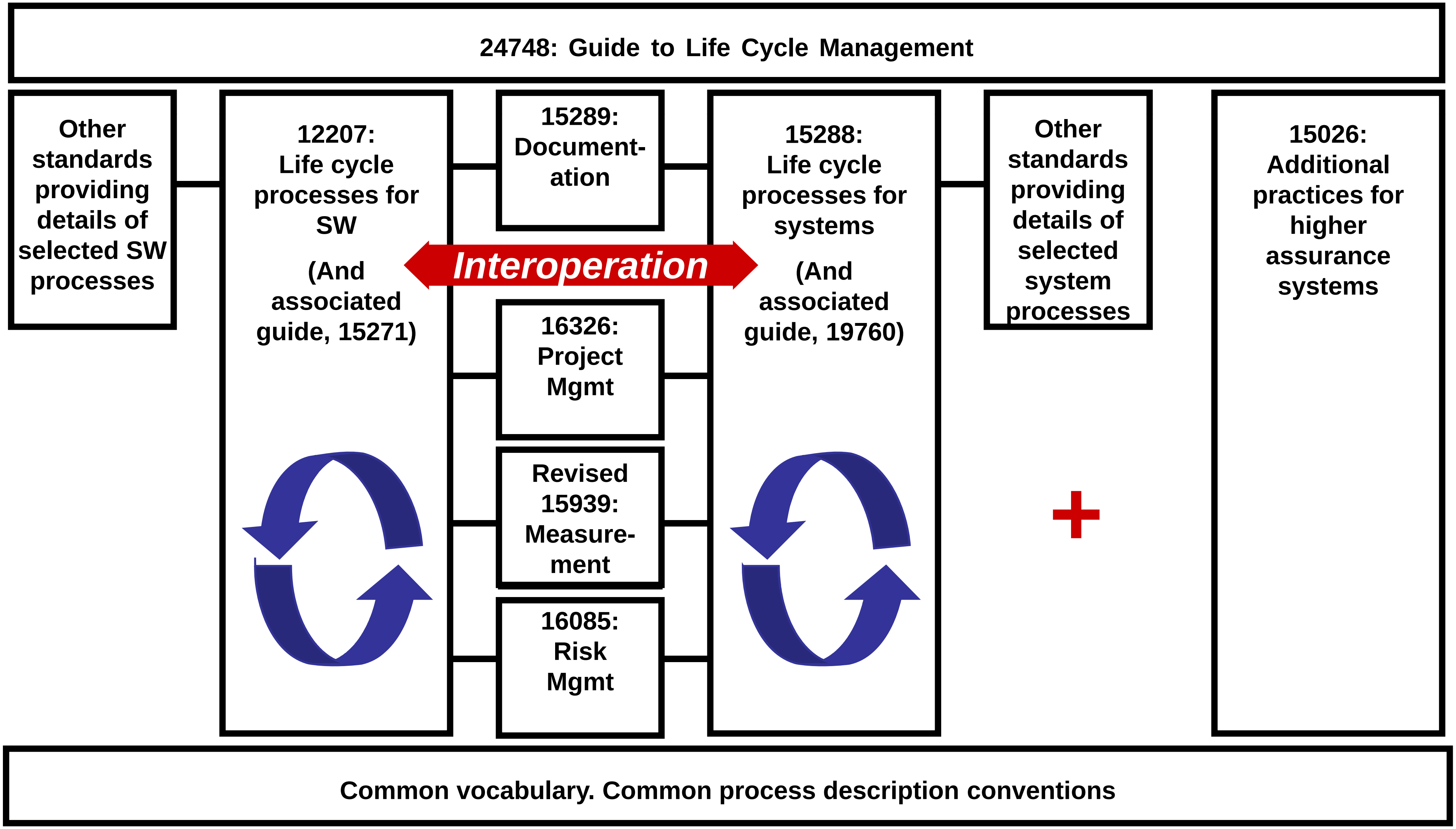

More exciting

More effective

Introduction

- ISO/IEC JTC 1/SC 7 (software and systems engineering) has a large collection of standards.
    - Some of the key standards are difficult to use together.
- IEEE Software and Systems Engineering Standards Committee has a large collection of standards.
    - Some of the key standards are not completely consistent with the ISO/IEC standards
- IEEE Computer Society and ISO/IEC JTC 1/SC 7 have entered into a program to "harmonize" their key standards to provide a shared, common framework, e.g.
    - A single shared set of processes.
    - A single shared vocabulary.

Intended Relationships of Key System and Software Engineering Life Cycle Process Standards



24748: Guide to Life Cycle Management

Other standards providing details of selected SW processes

12207: Life cycle processes for SW

(And associated guide, 15271)

15289: Document-ation

Interoperation

16326: Project Mgmt

Revised 15939: Measure-ment

16085: Risk Mgmt

15288: Life cycle processes for systems

(And associated guide, 19760)

Other standards providing details of selected system processes

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15026: Additional practices for higher assurance systems

Common vocabulary. Common process description conventions

New Vocabulary Standard

- Systems and software engineering vocabulary
- Publicly available website http://www.computer.org/sevocab/
- Provides access to 4100 authoritative definitions of systems and software engineering terms
- Definitions may be reprinted (with attribution).
- Currency of database will be maintained by a vocabulary standards project coordinated between IEEE and ISO/IEC JTC 1/SC 7, and published as ISO/IEC/IEEE 24765.
- Sources:
  - IEEE standards
  - ISO/IEC standards
  - PMBOK® Guide, Third edition
  - Other sources

Software Development Professional Certifications

What is Certification?

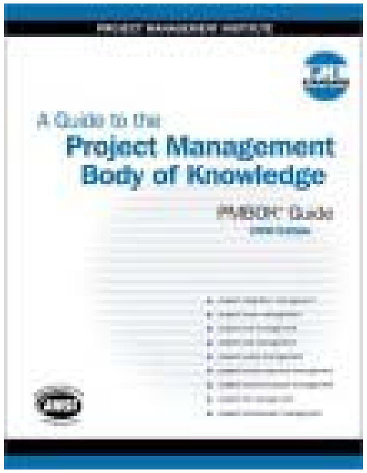
- **Formal recognition** of demonstrated proficiency within and comprehension of a specified body of knowledge at a point in time.
- It is **peer recognition** and not registration or licensure.
  - ***Registration:*** listing by and with a body of individuals or organizations that are certified
  - ***Licensure:*** authorization granted by government body for an individual or organization to practice a business or occupation
- Certification is ***voluntary*****.**

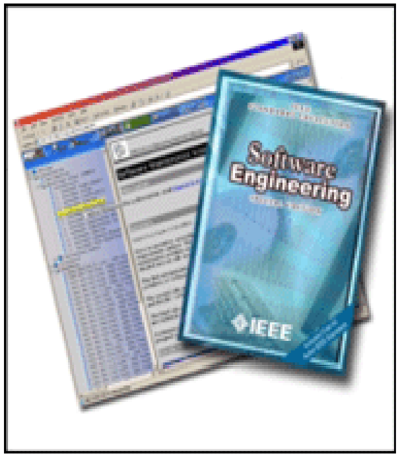
Three Types of Certification

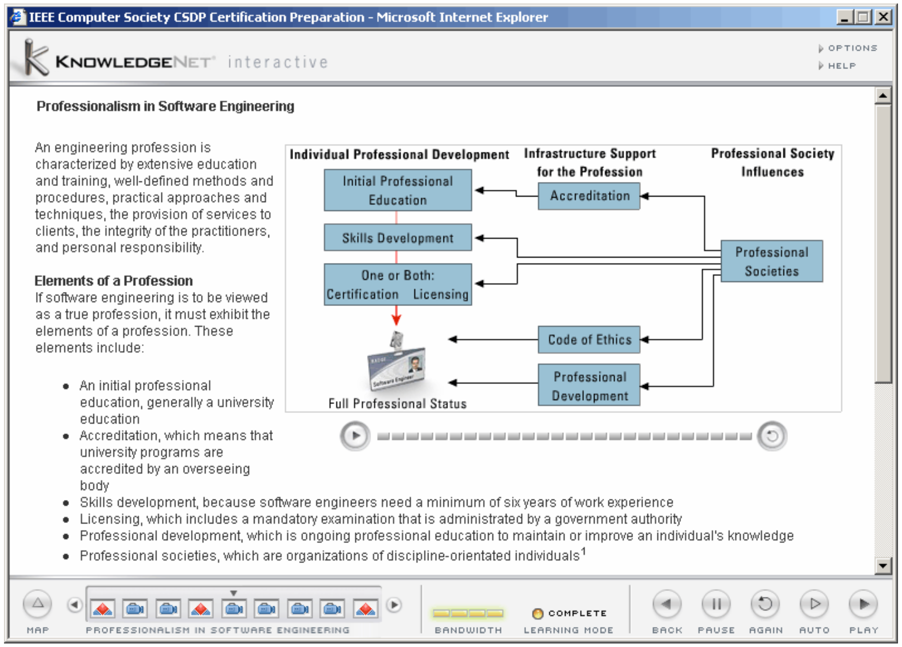
- ***Training-related***
  - – Completion of a set of courses
  - – (This is sometimes called a “certificate” rather than a “certification”.)
- ***Product-related***
  - – Knowledge of a particular product or product line
  - – e.g. MCSE, CNE
- ***Professional***
  - – Mastery of a long-lived set of principles and ethics fundamental to practice in a professional field
  - – e.g. PMP, CSDP, CSQE, PHR

Basis for Professional Certifications

- Professional certifications are usually founded on professional society norms such as:
  - A Code of Ethics: *IEEE-CS/ACM Software Engineering Code of Ethics*
  - A specified Body of Knowledge: *IEEE-CS Guide to the Software Engineering Body of Knowledge**
  - A set of professional practice standards: *IEEE and international standards on software engineering*
- … and supported by appropriate training programs and materials.






IEEE Computer Society CSDP Certification Preparation - Microsoft Internet Explorer
KNOWLEDGENET interactive
OPTIONS
HELP

Professionalism in Software Engineering

An engineering profession is characterized by extensive education and training, well-defined methods and procedures, practical approaches and techniques, the provision of services to clients, the integrity of the practitioners, and personal responsibility.

Elements of a Profession
If software engineering is to be viewed as a true profession, it must exhibit the elements of a profession. These elements include:

- An initial professional education, generally a university education
- Accreditation, which means that university programs are accredited by an overseeing body
- Skills development, because software engineers need a minimum of six years of work experience
- Licensing, which includes a mandatory examination that is administrated by a government authority
- Professional development, which is ongoing professional education to maintain or improve an individual's knowledge
- Professional societies, which are organizations of discipline-orientated individuals[1]

Individual Professional Development
Infrastructure Support for the Profession
Professional Society Influences
Initial Professional Education
Accreditation
Skills Development
Professional Societies
One or Both: Certification Licensing
Code of Ethics
Professional Development
Full Professional Status
MAP
PROFESSIONALISM IN SOFTWARE ENGINEERING
BANDWIDTH
COMPLETE
LEARNING MODE
BACK
PAUSE
AGAIN
AUTO
PLAY

* http://www.swebok.org

IEEE Computer Society Certified Software Development Professional (CSDP)

- Reflects an *engineering* viewpoint of professionalism.
  - Anticipates career progression similar to engineers.
  - Designed for baccalaureate plus four years of experience.

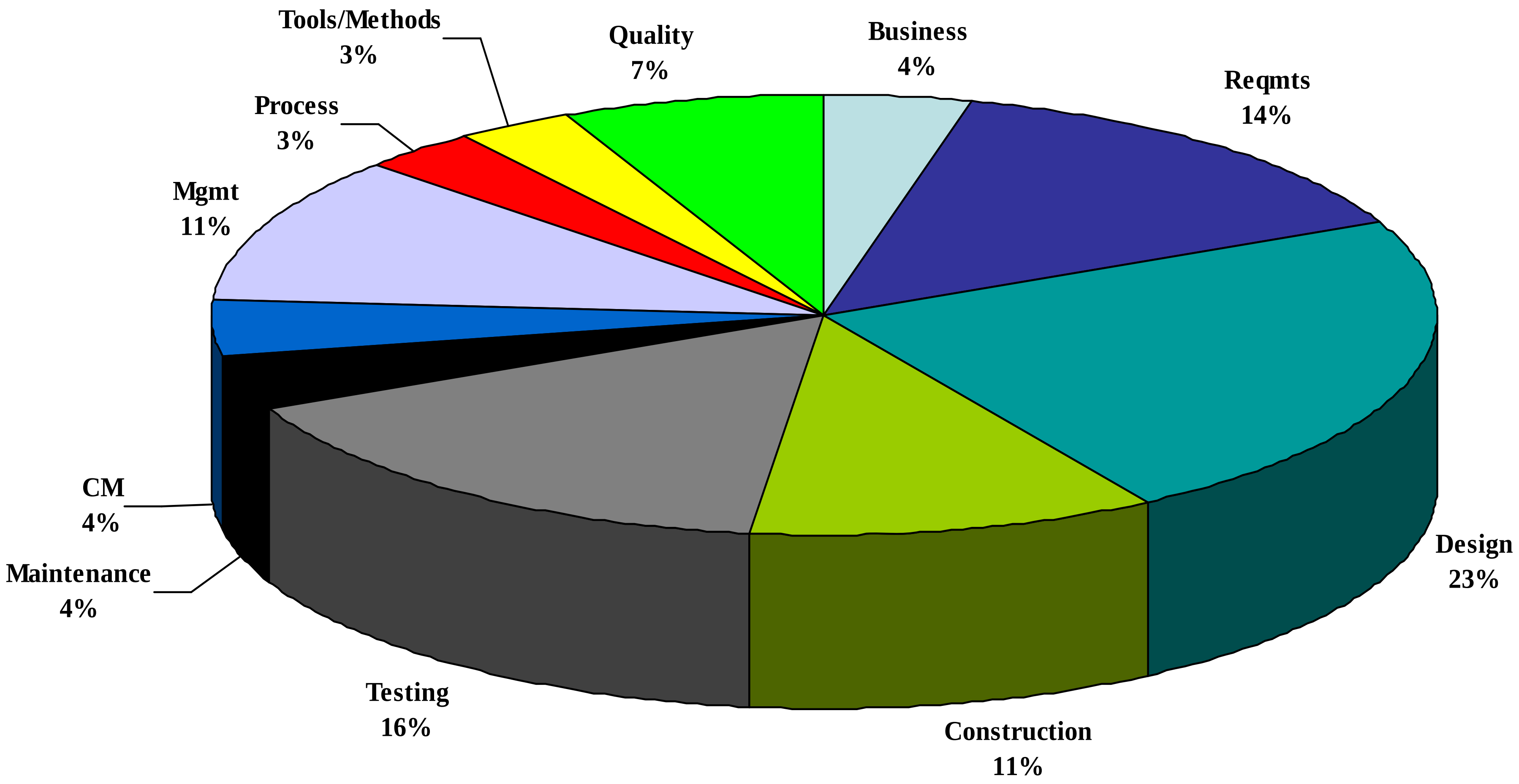
- Certification based on:
  - education,
  - experience,
  - examination,
  - code of ethics, and
  - continuing education.
- Developed to be *fair*, *reliable* and *valid*.

First public exam in April 2002. To date, about 600 certifications.

Examination for CSDP Certification

- Four-hour written examination
- Multiple-choice questions selected from a pool of questions across each of the knowledge areas
- Total of 180 questions
  - 150 are graded
  - 30 are being validated for future exams
- Closed book, calculators provided
- Computer-based test
  - Result provided almost immediately

Approximate Distribution of Questions



Re-certification

- Every 3 years
- Requires 30 re-certification credits
  - 3 credits/year for employment in SW engineering
  - 2 credits/semester hour for graduate courses
  - 5-10 credits for publishing a paper in the field
  - 0.3 credits/hour for preparing/giving a presentation
  - 3-5 credits for some forms of service to a professional society (NOT just for membership in a professional society)
  - Also self-study, writing questions for CSDP exam, etc.
- Fee: Currently $150 member / $250 non-members
- No re-exam required if you re-certify within 3 years

Why Become Certified?

- ***Mark of Excellence***: demonstrates the certified individual has the knowledge to ensure that recognized principles and practices of software engineering are being used.
- ***Competition in the Marketplace***: companies and organizations need a work force proficient in principles and practices of software engineering that can work across borders.
- ***Recognition***: Customer confidence based on your evidence of qualifications and suitability for the task or project.

Why Become Certified? (continued)

- ***Investment:*** certification is an investment in your career and the future of your employer
- ***Continuous improvement:*** to remain certified requires you to continue your education and involvement in software engineering-related work and activities.

Your skills remain current and your flexibility to work on a variety of projects or for a variety of companies improves.

11 Knowledge Areas for CSDP

- Software Requirements
- Software Design
- Software Construction
- Software Testing
- Software Maintenance
- Software Configuration Management
- Software Engineering Management
- Software Engineering Process
- Software Tools and Methods
- Software Quality
- Business Practices & Engineering Economics

(The next refresh of the CSDP will achieve complete alignment of SWEBOK Guide and CSDP.)

Same as SWEBOK

+

Distance learning course

- Provides 10 modules of content for a total of 16 hours of learning
- Four months of 24x7 access
- Developed with KnowledgeNet/NETg
- Recently updated to provide more comprehensive preparation

http://computer.org/certification/distancelearning

Books and Other Materials

- Much study material is listed on the certification web site.
- In addition, a new book provides sample examination questions and answers:
  - *IEEE Computer Society Real-World Software Engineering Problems: A Self-Study Guide for Today's Software Professional (Practitioners),* available at the CS Online store at http://www.computer.org

Code of Ethics

Software Engineering Code of Ethics and Professional Practices

- Developed by a Joint IEEE-CS/ACM Task Force on Software Engineering Ethics and Professional Practices. Approved in 1998.

"The short version of the code summarizes aspirations at a high level of the abstraction; the clauses that are included in the full version give examples and details of how these aspirations change the way we act as software engineering professionals. Without the aspirations, the details can become legalistic and tedious; without the details, the aspirations can become high sounding but empty; together, the aspirations and the details form a cohesive code."

Short Version States Eight Principles

- ***Public:*** Software engineers shall act consistently with the public interest.
- ***Client and employer:*** Software engineers shall act in a manner that is in the best interests of their client and employer consistent with the public interest.
- ***Product:*** Software engineers shall ensure that their products and related modifications meet the highest professional standards possible.
- ***Judgment:*** Software engineers shall maintain integrity and independence in their professional judgment.
- ***Management:*** Software engineering managers and leaders shall subscribe to and promote an ethical approach to the management of software development and maintenance.
- ***Profession:*** Software engineers shall advance the integrity and reputation of the profession consistent with the public interest.
- ***Colleagues:*** Software engineers shall be fair and supportive of their colleagues.
- ***Self:*** Software engineers shall participate in lifelong learning regarding the practice of their profession and shall promote an ethical approach to the practice of the profession.

Example from Long Version

Principle 4 JUDGMENT Software engineers shall maintain integrity and independence in their professional judgment. In particular, software engineers shall, as appropriate:

4.01. Temper all technical judgments by the need to support and maintain human values.

4.02. Only endorse documents either prepared under their supervision or within their areas of competence and with which they are in agreement.

4.03. Maintain professional objectivity with respect to any software or related documents they are asked to evaluate.

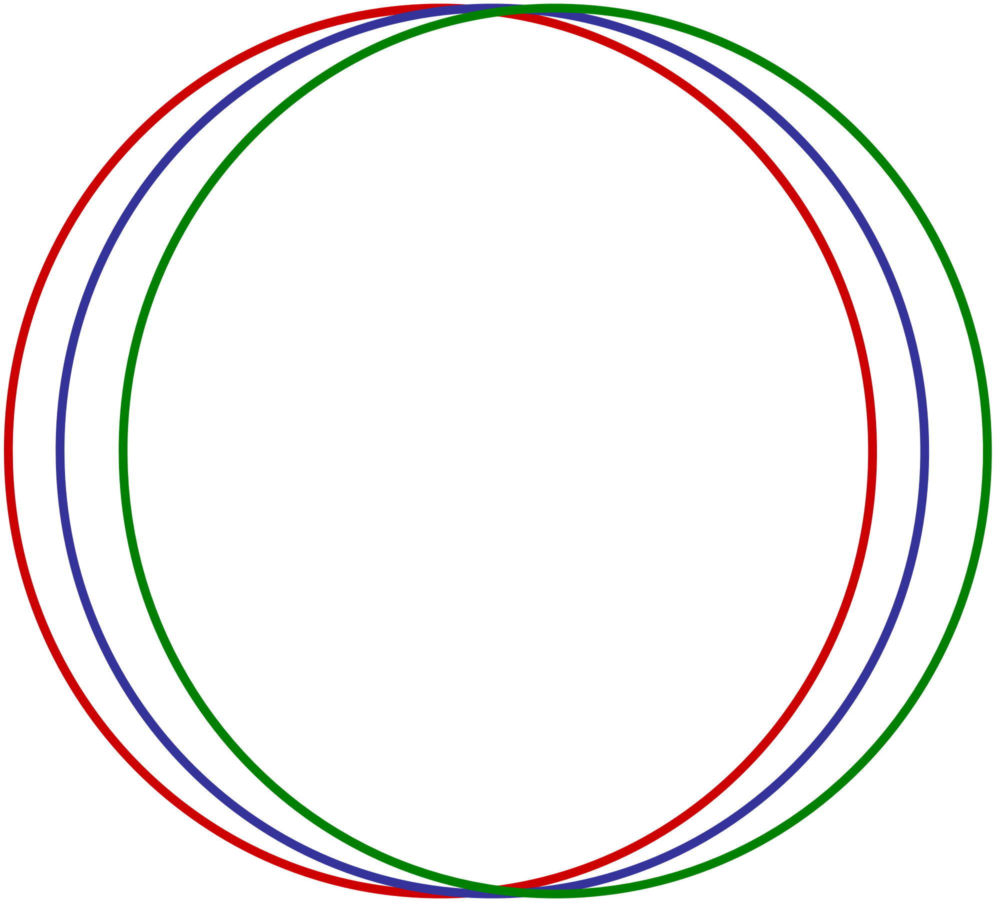
4.04. Not engage in deceptive financial practices such as bribery, double billing, or other improper financial practices.

4.05. Disclose to all concerned parties those conflicts of interest that cannot reasonably be avoided or escaped.

4.06. Refuse to participate, as members or advisors, in a private, governmental or professional body concerned with software related issues, in which they, their employers or their clients have undisclosed potential conflicts of interest.

Plans for the Future

Substantial Agreement on Scope of Software Engineering



SWEBOK, CSDP, and SE2004 each characterized the scope of software engineering.

Each followed its own consensus process.

The extent of agreement among the three is remarkable.

It is a powerful validation of the characterization.

Nevertheless, the minor differences need to be resolved.

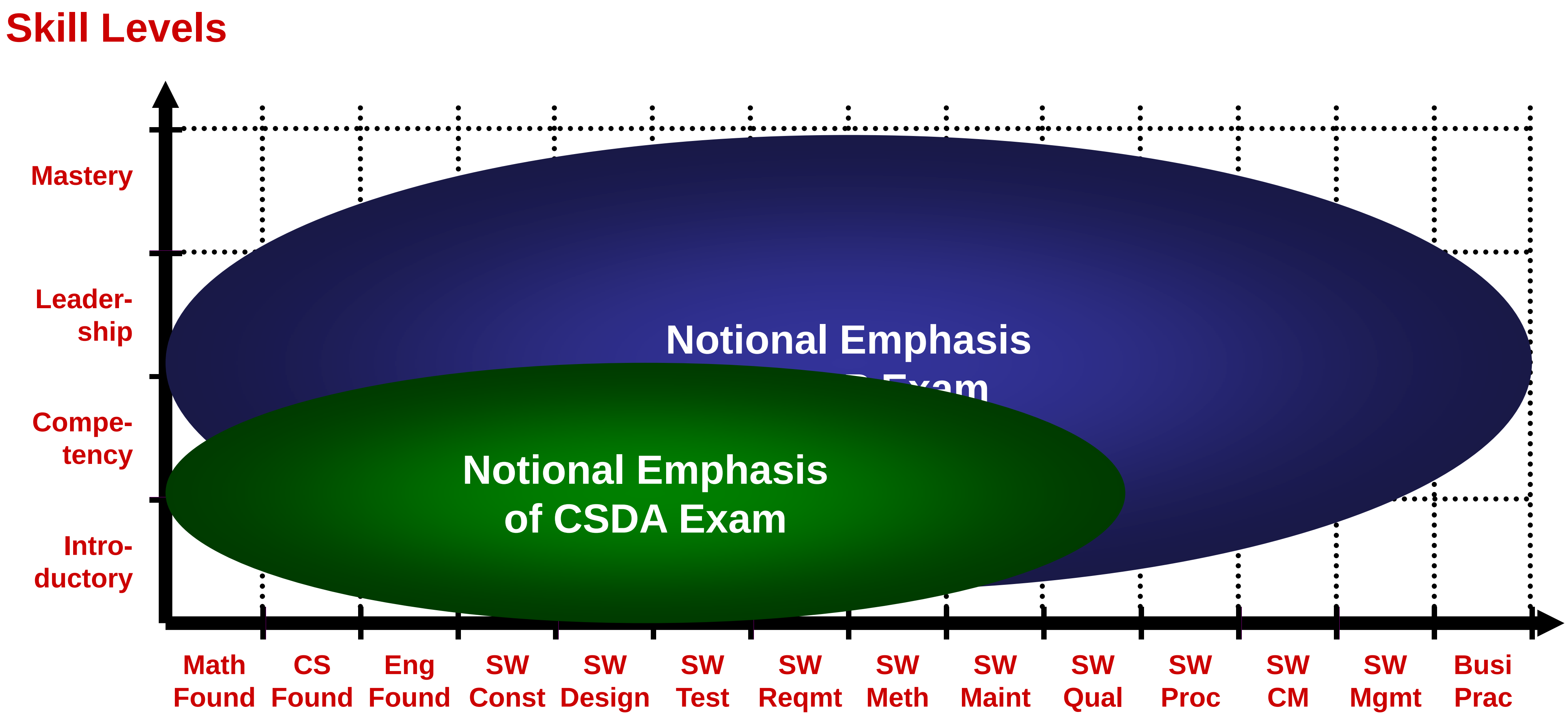
Plans for SWEBOK Guide

- The next version of the SWEBOK Guide will have a broadened scope that spans the consensus achieved by:
  - The 2004 SWEBOK Guide
  - The SE 2004 Curriculum
  - The CSDP Test Specification
- New Knowledge Areas:
  - Mathematical Foundations
  - Computing Foundations
  - Engineering Foundations
  - Engineering Economy Foundations
  - Professional Practice
- Some additions and realignment of material in the existing ten knowledge areas
  - Notably, a strengthened treatment of “methods”

Plans for Entry-Level Certification

- Certified Software Development Associate (CSDA)
- Suitable for:
  - New graduates from software engineering programs
  - Others who wish to enter the software engineering profession
- Aligned with the plans for the SWEBOK Guide revision
- Cost and other details are not yet determined.
- Goal for availability is 2Q2008.

Relationships of Certifications



Knowledge Areas shared by SWEBOK and Certifications

(roughly ordered with suitability for university teaching toward the left and suitability for industrial experience toward the right)

Plans for CSDP

- CSDP is being “refreshed”
  - New questions to ensure currency of material
  - Alignment with the plans for the SWEBOK Guide revision