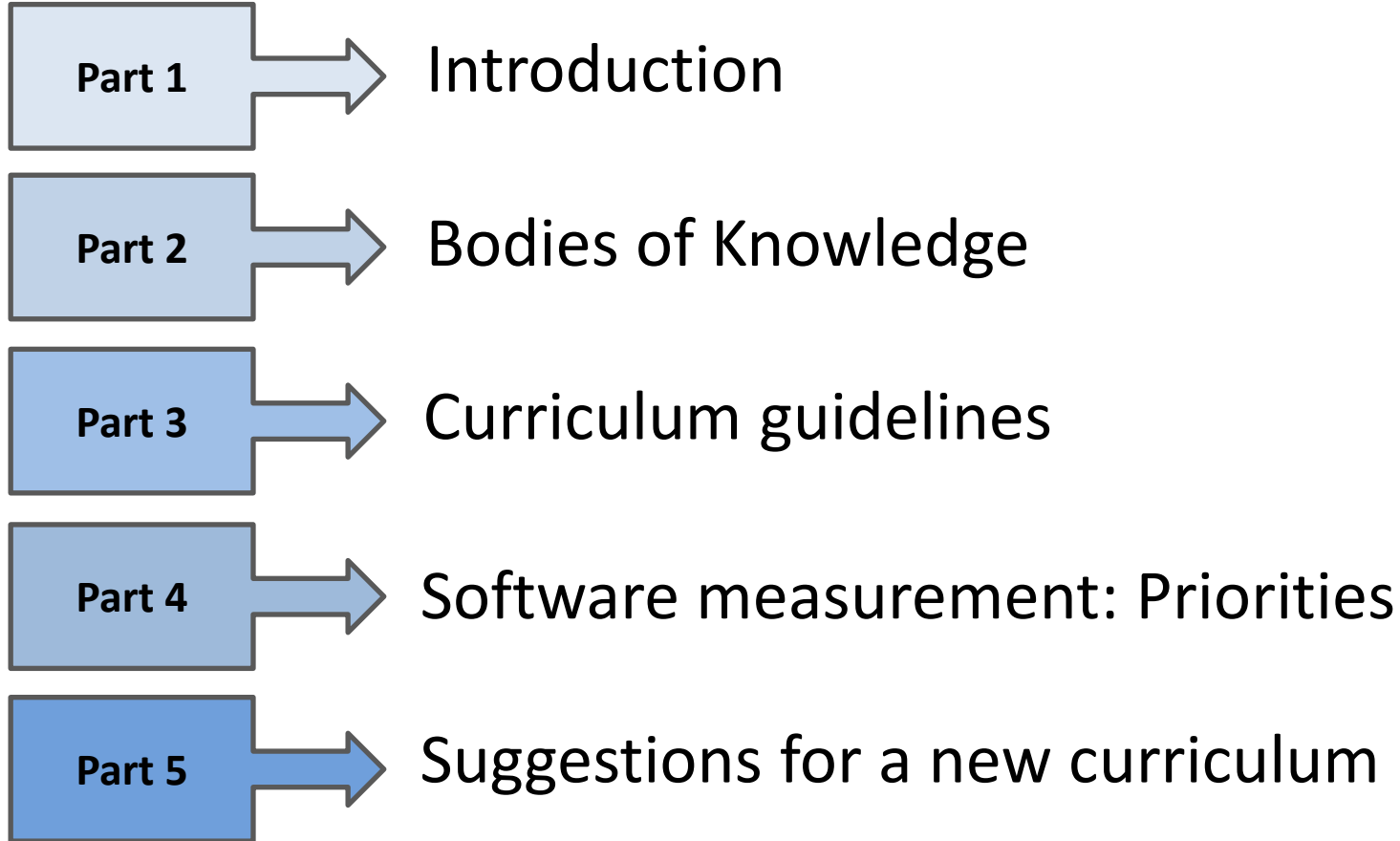




# Software measurement for undergraduates: Suggestions for a software engineering curriculum

Mónica Villavicencio  
Alain Abran

# Agenda



# INTRODUCTION

# Introduction

- SWEBOK
  - new version (v3) - 2014
- Curriculum guidelines 2004
  - SE2004
  - SEEK
- **Expectation:** SWEBOK v3.0 will contribute to the updating of the software engineering curriculum guidelines.

Until software size, quality, and productivity can be measured with precision the phrase “software engineering” is a misnomer

- *Caper Jones, 2008* -

# Objective

To address the need of having a new curriculum guidelines for software engineering undergraduate programs by providing a set of suggestions regarding the topics of software measurement to be emphasized in undergraduate programs.

# **BODIES OF KNOWLEDGE**

# Bodies of Knowledge

- **SWEBOK** (Software Engineering Body of Knowledge) – V3.0
- **SEEK** (Software Engineering Education Knowledge)
- **Software Measurement Body of Knowledge**



# SWEBOK V3.0

- Characterization of the software engineering profession.
- Foundation for curriculum development
- 15 Knowledge Areas - KA
  - 11 KA include software measurement topics

<b>SWEBOK V3.0</b>		
<b>Knowledge Areas</b>	<b>Topics</b>	<b>Sub-Topics</b>
Software Requirements	Practical Considerations	Measuring Requirements
Software Design	Software Design Quality Analysis and Evaluation	Measures
Software Construction	Managing Construction	Construction Measurement
Software Testing	Test Related Measures	
Software Maintenance	Key Issues in Software Maintenance	Software Maintenance Measurement
Software Configuration	Management of the SCM Process	Surveillance of Software Configuration
Software Engineering Management	Software project planning	Effort, Schedule and Cost Estimation
	Software engineering measurement	
Software Engineering Process	Software process definition	
	Software Life Cycle	Categories of Software Processes
	Software Process Assessment and Improvement	Software Process Improvement Models
	Software measurement	
Software Engineering Models and Methods		
Software Quality	Practical Considerations	Software Quality Measurement
Software Engineering Professional Practice		
Software Engineering Economics	Life Cycle Economics	Performance Measurement
Computing Foundations		
Mathematical Foundations		
Engineering Foundations	Measurement	

# SEEK

- Software Engineering Education Knowledge - SEEK
- Based on SWEBOK 2004
- Used to develop the SE curriculum guidelines for undergraduate degree programs (SE2004)
- 10 Knowledge Areas (KA)
- 6 KA include software measurement topics

<b>Software Engineering Education Knowledge (SEEK)</b>	
<b>Knowledge Areas</b>	<b>Topics</b>
Mathematical and Engineering Fundamentals	Measurement and metrics
	Theory of measurement
Software Design	Measures of design attributes (e.g. coupling, cohesion, etc.)
	Design metrics (e.g. architectural factors, interpretation, etc.)
Software Verification and Validation	Metrics & Measurement (e.g. reliability, usability, etc.)
	Analyzing failure reports
	Defect analysis
Software Process	Quality analysis and control (e.g. defect prevention, quality metrics, root cause analysis, etc.)
	Individual software process (model, definition, measurement, analysis, improvement)
	Team process (model, definition, organization, measurement, analysis, improvement)
Software Quality	Software quality models and metrics
	Quality product metrics and measurement
Software Management	Effort estimation
	Measurement and analysis of results

# Software Measurement Body of Knowledge

- Full body of knowledge: 2010
- Integrates and expands the measurement-related knowledge contained throughout SWEBOK 2004.

# **CURRICULUM GUIDELINES**

# Curriculum guidelines

- SE2004: Curriculum guidelines for undergraduate degree programs in software engineering.
- Content of programs
- Skills (technical and managerial) needed by undergraduate students to deal with software development processes.

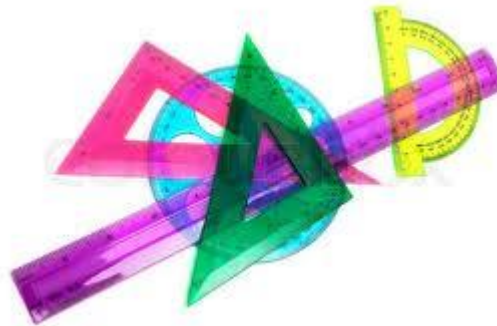
# Software Engineer: Characteristic

*“Engineers measure things, and when appropriate, work quantitatively; they calibrate and validate their measurements; and they use approximations based on experience and empirical data”.*





# Engineers measure



# Software measurement

- Perform objective planning and estimation;
- Monitor and verify the progress of projects in course;
- Observe trends;
- Have a quantitative and objective basis for software process improvement;
- Experimentally validate best practices;
- Do benchmarking;
- Make better decisions.

# The adoption of software measurement programs is still rather low.

- Software measurement is not usually taught in universities.

*Software engineers could pass through a curriculum without learning measurement.*

*- Caper Jones, 2008-*

- Measuring is considered as a tough work.

# **MAPPING AMONG BODIES OF KNOWLEDGE**

# Relationship of BoK with respect to Sw. measurement topics

Software Engineering Education Knowledge (SEEK) and SE2004		Software Measurement Body of Knowledge		SWEBOK v3	
Knowledge Areas	Topics	Major Topics	Sub Topics	Knowledge Areas	Topics
Mathematical and Engineering Fundamentals	Measurement and metrics	Basic concepts	Foundations	Engineering foundations	Measurement
	Theory of measurement		Definition and concepts		
Software Design	Measures of design attributes (e.g. coupling, cohesion, etc.)	Measures by SLC	Software design	Software design	Software design quality analysis and evaluation
	Design metrics (e.g. architectural factors, interpretation, etc.)	N/F	N/F	N/F	N/F
Software Verification and Validation	Metrics & Measurement (e.g. reliability, usability, etc.)	Measures by SLC	Software testing	Software testing	Test related measures
	Analyzing failure reports				
	Defect analysis				
Software Process	Quality analysis and control (e.g. defect prevention, quality metrics, root cause analysis, etc.)	Techniques and Tools	Measurement techniques	Software engineering process	Software measurement
	Individual software process (model, definition, measurement, analysis, improvement)				Measurement techniques
	Team process (model, definition, organization, measurement, analysis, improvement)	N/F	N/F		Software process definition
Software Quality	Software quality models and metrics	Measures by SLC	Software quality	Software quality	Practical considerations - Software Quality Measurement
	Quality product metrics and measurement				
Software Management	Effort estimation	Measures by SLC	Software construction	Software engineering management	Software project planning
			Software testing		
	Measurement and analysis of results	Techniques and tools	Measurement tools		Perform, Evaluate the measurement process

N/F: Not Found

# MAPPING AMONG BODIES OF KNOWLEDGE

## SEEK + SE2004

## SW. MEAS BOK

## SWEBOK V3

Software Management	Effort estimation	Measures by SLC	Software measurement for Construction and Testing	Software Engineering management	Software project planning
	Measurement and analysis of results	Techniques and Tools	Measurement tools		Software engineering measurement
	Measurement Process	Perform, Evaluate the measurement process			

# **SOFTWARE MEASUREMENT: PRIORITIES**

# Identification of priorities

Ethics Committee



Web survey



Delphi Study



30 experts

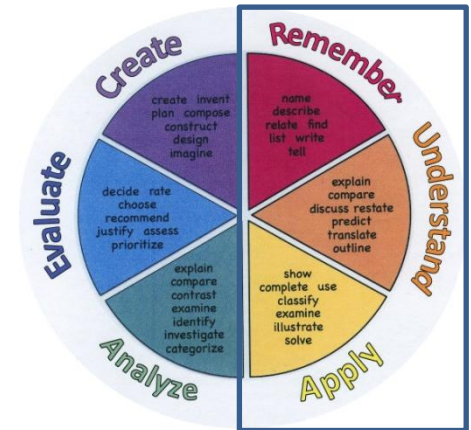


4 book writers  
50 teachers & pract.



## PRIORITIES FOR UNDERGRADUATES

1	Basic concepts in software measurement
2	The measurement process
3	Sw measurement techniques & tools
4	Software management measures
5	Measures for the requirements phase



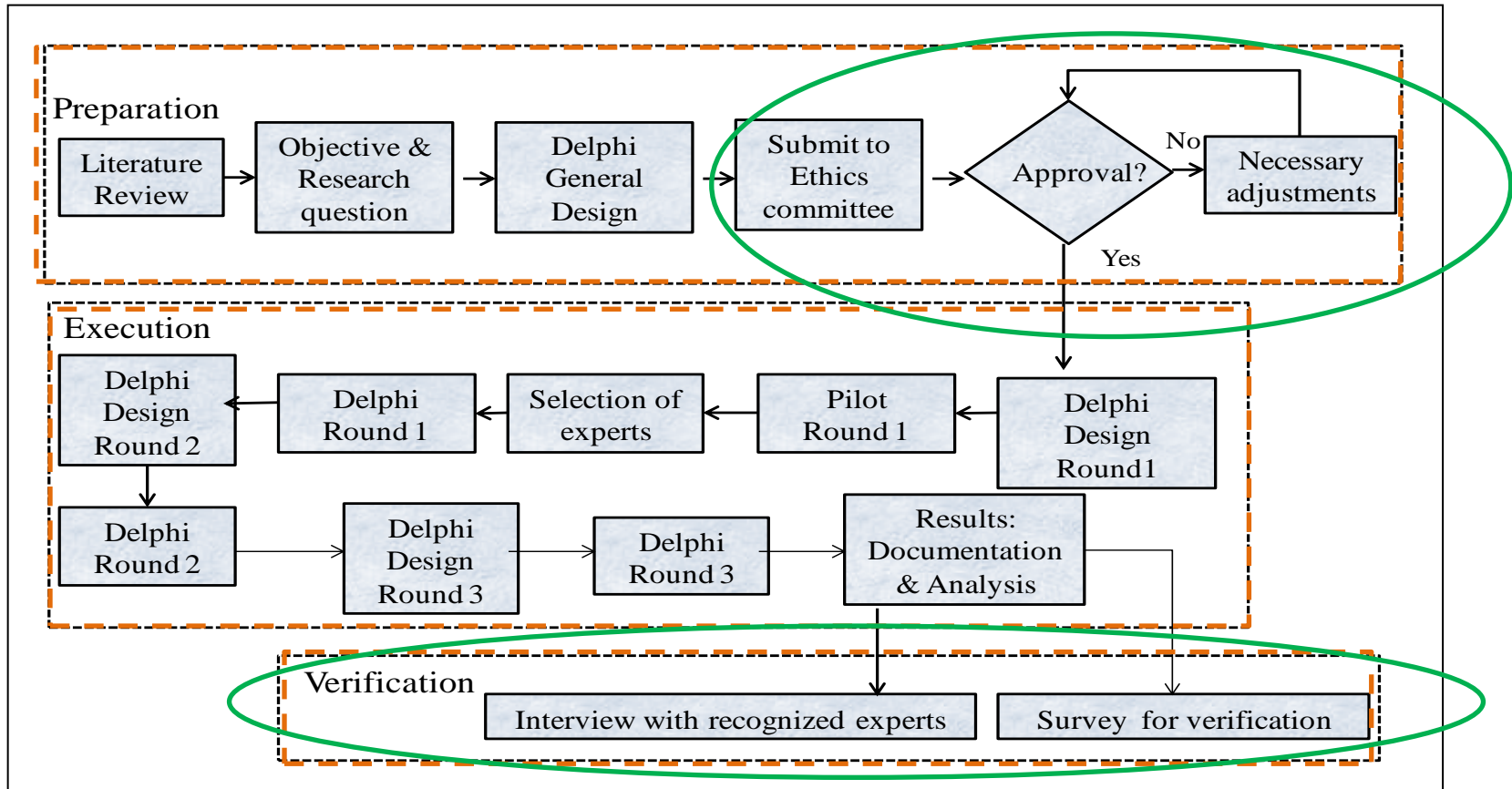
Sw.measurement topics  
Teaching & assessment  
approaches



# Web survey

- Objectives:
  1. The level of importance perceived by practitioners regarding software measurement;
  2. How organizations appreciate software measurement knowledge exhibited by graduating students when they become their employees;
  3. *What specific software measurement topics should be emphasized in software engineering education from the practitioners point of view*

# Delphi study



**General view of the Delphi study** - adapted from Okoli and Pawlowski, 2004

# Delphy study

- Objective: To reach consensus among university teachers and practitioners -with proven experience in the field- regarding software measurement topics that should be taught to undergraduate students.

# Delphi study: Participants

## EXECUTION

### University teachers

- Experience
- Publications
- Members of committees



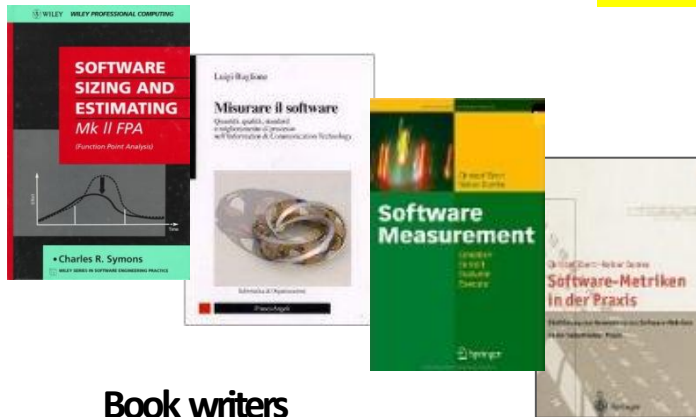
### Practitioners

- Experience
- Publications
- Members of committees
- Post secondary education



## VERIFICATION

### Book writers



**MIWSM**  
**MENSURA**



### Conference attendees

# The Priorities

## PRACTITIONERS

SOFTWARE MEASUREMENT TOPICS
1 Basic concepts in software measurement
2 The measurement process
3 Sw measurement techniques & tools
4 Software management measures
5 Measures for the requirements phase
6 Measures for the design phase
7 Measures for the construction phase
8 Measures for the testing phase
9 Measures for the maintenance phase
10 Software quality measurement
11 Measurement standards
12 Software measurement repositories
13 Measures for configuration management

### WEB SURVEY - NON CERTIFIED

1 Basic concepts in sw measurement
2 Software management measures
3 Sw measurement techniques & tools
4 Software quality measurement
5 The measurement process

### WEB SURVEY - CERTIFIED

1 Basic concepts in sw measurement
2 The measurement process
3 Measurement standards
4 Measures for the requirements phase
5 Sw measurement techniques & tools

Web survey

Delphi study

### PRIORITIES FOR UNDERGRADUATES

1 Basic concepts in sw measurement
2 The measurement process
3 Sw measurement techniques & tools
4 Software management measures
5 Measures for the requirements phase
6 Measures for the design phase

## PRACTITIONERS-TEACHERS

LEVELS OF LEARNING PER TOPIC
<b>BASIC CONCEPTS IN SOFTWARE MEASUREMENT</b>
Can remember software measurement terminology and concepts
Can give examples of basic concepts, measurement methods and procedures
Can explain the above
Can use terminology and concepts in a given exercise or project
<b>THE MEASUREMENT PROCESS</b>
Can remember the measurement process
Can use the measurement process in a given project/situation
<b>TECHNIQUES AND TOOLS FOR SOFTWARE MEASUREMENT</b>
Can remember the existing software measurement techniques and tools
Can give an example of software measurement techniques and tools
Can follow a technique in an exercise or project
<b>SOFTWARE MANAGEMENT MEASURES</b>
Can remember concepts related to effort estimation, and measures for project planning and control
Can explain how to estimate the effort of a project
Can measure time and effort in a project
<b>MEASURES FOR THE REQUIREMENTS PHASE</b>
Can remember the most common functional size measurement methods
Can obtain the functional size of the software in an exercise or project by following a measurement method

# **SUGGESTIONS FOR A SOFTWARE ENGINEERING CURRICULUM**

# Standardization of knowledge areas (KA)

- Now: KAs and topics have similar content but different names.
- Suggestion: use the same name of KAs and topics that appear in the SWEBOK guide rather than using new or similar names.
  - Example: Use Software Requirements (SWEBOK v3.0) instead of Software Modeling and Analysis (SEEK-SE2004)

# Versions of taxonomies

- Now: Bloom's taxonomy (original version).
- Suggestion: Use the revised version of the taxonomy released by Anderson et al in 2001.
  - (i.e. from Knowledge to Remember; from Comprehension to Understand; from Application to Apply; and so on).



# Focus on priorities

- Now: All the topics related to software measurement included in SEEK are considered essential (E).
- Suggestions:
  - Consider the identified priorities of software measurement topics as essential (E).
  - Contain the software measurement topics, levels of learning (L) and relevance (R) identified in the studies.

# Proposal for the Software Engineering Education Knowledge (SEEK)

Knowledge Areas (taken from SWEBOK v3.0)	Knowledge Units (suggested)	SEEK from SE2004			SUGGESTIONS for updating the software engineering curriculum guidelines based on SWEBOK v3.0		
		Topics	L	R	Topics	L	R
Mathematical and Engineering Fundamentals	Engineering foundations for software	Measurement and metrics	K	E	Basic concepts of software measurement (definition, units, scales, etc)	A	E
		Theory of measurement	C	E			
Software Requirements	Software requirements measurement	<i>Not found in SEEK</i>			Functional size measurement (what is, methods)	A	E
Software Design	Software design quality analysis and evaluation	Measures of design attributes (e.g. coupling, cohesion, etc.)	K	E	Software design measures (object oriented and function oriented)	U	D
		Design metrics (e.g. architectural factors, interpretation, etc.)	A	E	<i>Not found in SWEBOK v3.0 (a revision is suggested)</i>		
Software engineering Process	Software process measurement techniques	Measurement and analysis of software processes	C	E	Introduction to Software Process Measurement techniques and models (root cause analysis, improvement and assessment of processes, examples of models and methods for software process measurement)	A	E
		Quality analysis and control (e.g. defect prevention, quality metrics, root cause analysis, etc.)	C	E			
		Individual software process (model, definition, measurement, analysis, improvement)	C	E			
		Team process (model, definition, organization, measurement, analysis, improvement)	C	E			
Software Quality	Software quality measurement	Software quality models and metrics	C	E	Software quality measurement (the cost of quality, related standards and models that include measurement such as ISO/IEC/ IEEE12207 and CMMI)	R	D
		Quality product metrics and measurement	C	E			
Software Engineering Management	Software project planning	Effort estimation	A	E	Effort estimation	A	E
	Software engineering measurement	Measurement and analysis of results	A	E	Measurement and analysis of results	U	D
		<i>Not found in SEEK</i>			The measurement process	A	E

**From 12 to 5 essential topics**

# Proposal for the Software Engineering Education Knowledge (SEEK)

KA	UNITS	NOW			PROPOSAL		
Software Engineering Management	Software project planning	Effort estimation	A	E	Effort estimation	A	E
	Software engineering measurement	Measurement and analysis of results	A	E	Measurement and analysis of results	U	D
		<i>Not found in SEEK</i>			The measurement process	A	E



