

# Empirical Methods in Software Engineering (01 OPJIU)

---

## Introduction

<http://softeng.polito.it/EMSE/>



**SoftEng**  
<http://softeng.polito.it>

© Marco Torchiano, 2013



### Attribution-NonCommercial-NoDerivs 2.5

- You are free: to copy, distribute, display, and perform the work

Under the following conditions:



**Attribution.** You must attribute the work in the manner specified by the author or licensor.



**Noncommercial.** You may not use this work for commercial purposes.



**No Derivative Works.** You may not alter, transform, or build upon this work.

- For any reuse or distribution, you must make clear to others the license terms of this work.
- Any of these conditions can be waived if you get permission from the copyright holder.

**Your fair use and other rights are in no way affected by the above.**

This is a human-readable summary of the Legal Code (the full license) found at the end of this document

# Who

---

- Software Engineering group
  - ◆ Marco Torchiano
- And what about you?
  - ◆ Who are you?
  - ◆ Which is your research topic?
  - ◆ What do you expect from this course?

# Agenda

---

- Motivation
- Context
- Topics
- Exam rules
- Schedule

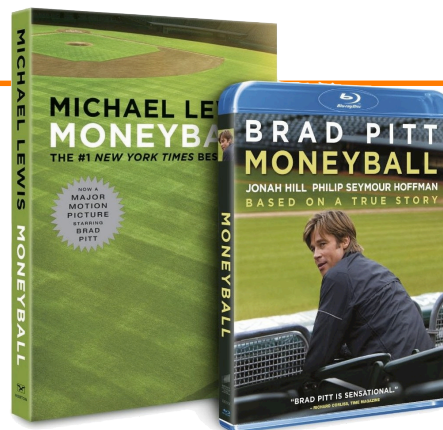
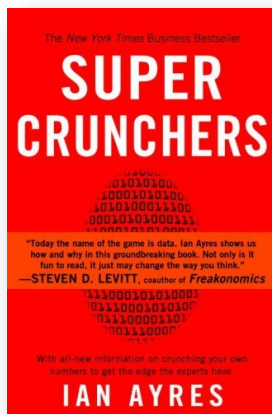
# Motivation

---

- An increasing number of empirical studies are being conducted
- A common basic knowledge is required
  - ◆ To improve quality of studies
  - ◆ To design and discuss the studies
  - ◆ To understand and assess them

## Not only Soft Eng

---



*the signal and the noise and the noise and the noise and the noise why so many predictions fail—but some don't the noise and the noise and the noise nate silver noise and the noise*



---

# SOFTWARE ENGINEERING

**SoftEng**  
<http://softeng.polito.it>

---



<http://homepages.cs.ncl.ac.uk/brian.randell/NATO/index.html>

# Software Engineering

---

- The origin of the discipline
  - ♦ Garmish 1968
  - ♦ NATO organized conference
    - Motivation was that the computer industry at large was having a great deal of trouble in producing large and complex software systems

# Software Engineering

---

Multi person construction of  
multi version software

- ♦ Parnas

# SE

---

A discipline that deals with the building of software systems which are so large that they are built by a team or teams of engineers

- ◆ Ghezzi, Jazayeri, Mandrioli

# SE

---

- Sub-discipline of computer science
  - ◆ defining models, techniques, methods and tools to **support** the development of large software systems based on sound engineering principles
  - ◆ defining models, techniques, methods and tools to **manage** software development projects and organizations
  - ◆ empirically **evaluating** the effectiveness of models, techniques, methods and tools in specific contexts
    - Rombach

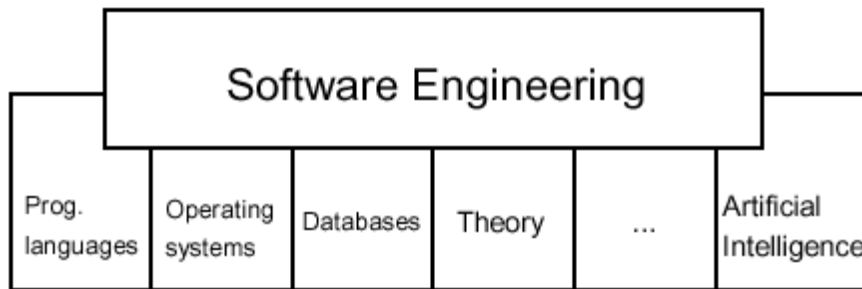
Software is our concern...



...and software development too

# SE and CS

---



- Software engineering builds on the foundations of other computer science disciplines
- Also influenced their development
  - ♦ strong links in both directions

**SoftEng**  
<http://softeng.polito.it>

---

# SE and CS

---

- Programming languages
  - formal languages to describe reqmts and designs
  - modularity concepts in new programming languages (e.g. Modula, C++, Ada)
- Operating Systems
  - first experience with large systems (principles such as virtual machines, layers ...)
  - new operating systems (e.g. UNIX) contain simple development environments

**SoftEng**  
<http://softeng.polito.it>

---



# SE and CS

---

- Databases
  - manipulation of complex data structures
  - SE- data base technologies (OO)
- Theory
  - FSM-model for specification and verification ....
  - theory of abstract data types, reliability models
- Artificial Intelligence
  - Explorative Processes (e.g. Prolog for prototyping)
  - Expert systems – provide practical SE assistance (i.e. “Development Assistants”)

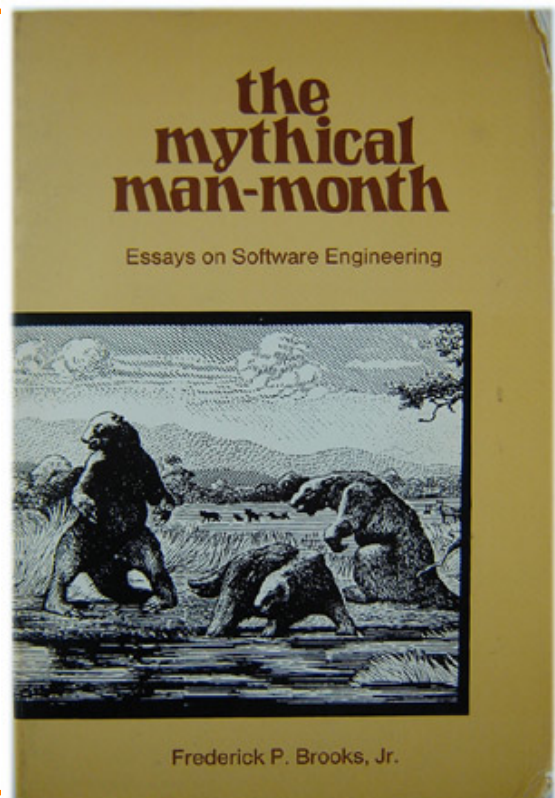
**SoftEng**  
http://softeng.polito.it

---

## The mythical man-month

---

- Fred Brooks, 1975



**SoftEng**  
http://softeng.polito.it

---

# SE Research Revisited

---

- Most software engineering research has followed a research–then–transfer methodology, with mixed results.
- We must do more than create new techniques, we must understand the old ones
- What is seen as major research problem is often trivial in practice

# SE Research Revisited

---

- We should pay more attention to human factors and not leave all the work to social psychologists
- Most of the research–then–transfer work that seeks to develop completely general tools is naïve.
- Changes that cannot be predicted can tell us a lot about what's really going on.
- Unless you know what to ask and what to measure, emphasis on quantitative data may be misguided

# Is SE a science?

---

- No foundations in physics, chemistry, biology, ..
- Huge impact of human factors (individual and organizational level)
- Regular hypes and fashions ..
  - ♦ CASE Tools, OO, agile, services, cloud, ..

# What is a science?

---

- Application of scientific method
  - ♦ Define hypothesis
  - ♦ Perform experiment to test hypothesis
    - If experiment contradict hypothesis, reject
    - Otherwise keep it
  - ♦ As more and more evidence accumulates, one or more hypotheses can form the basis for a scientific theory

# What is NOT a science

---

- Hypothesis that cannot be falsified is not scientific [K. Popper]
  - ♦ Gold is soluble in hydrochloric acid
    - False, scientific
  - ♦ Some homeopathic medicine does work
    - May be true
    - Unscientific because cannot be rejected by one experiment / observation report

# SE as a science

---

- Need to apply scientific method
- Need to empirically evaluate models, techniques and tools (empirical SE)
  - ♦ Is Java 'better' than C?
  - ♦ Is OO design 'better' than structured design?
  - ♦ Is agile 'better' than traditional?

# Other inspiring disciplines

---

- Social sciences
  - ◆ Effect of education, age and sex on income
  - ◆ Effect of immigration on crime
- Medicine
  - ◆ Effect of smoke on lung cancer
  - ◆ Effect of cholesterol on heart illnesses

## Myths and Facts of ESE

Myth	Fact
Scientific method is inapplicable	All we need is to observe a phenomenon, formulate hypotheses and test them
Current empirical level is enough	False when comparing to other disciplines
Experiments are expensive	Some experiments require a limited budget and often the return on investment pays off
Math demonstrations are enough	Demonstration are limited and can at most show the potentials
There is too much noise	Generally the noise can be separated from the subject
Experimentation hampers progress	Actually sound research favour progress
Technology changes too quickly	Research questions that lose interest rapidly are not worth while investigating
It is hard to publish	Small steps well validated can be easily published

# Publication venues

---

- Primarily focused on ESE
  - ♦ Empirical Software Engineering Journal
    - <http://www.springer.com/computer/swe/journal/10664>
  - ♦ ESEM – Empirical Software Engineering and Measurement Conferences
    - <http://www.esem-conferences.org/>
  - ♦ EASE – Evaluation and Assessment in Software Engineering Conference
    - <http://www.scm.keele.ac.uk/ease/>

# Publication venues

---

- Journals
  - ♦ TSE:
    - <http://www.computer.org/portal/web/tse>
  - ♦ IEEE Software:
    - <http://www.computer.org/portal/web/software/home>
  - ♦ IST
    - <http://www.journals.elsevier.com/information-and-software-technology/>
  - ♦ JSS
    - <http://www.journals.elsevier.com/journal-of-systems-and-software/>
- Conferences
  - ♦ ICSE: <http://www.icse-conferences.org/>
  - ♦ ICSM: <http://conferences.computer.org/icsm/>
  - ♦ ICPC: <http://www.program-comprehension.org/>

# Topics

---

- Empirical Method
- Systematic Literature Review
- Experimental Process
- Measurement
- Data analysis
- Surveys
- Action Research

# Exam rules

---

- Dirtying your hands with an experiment
  - ◆ Collective experiment
- Appraisal (alternative)
  - ◆ Perform a SLR
  - ◆ Characterize and assess empirical study

# Schedule

	Mon	Tue	Wed	Thu	Fri	Sat	Sun
	18	19	20	21	22	23	24
Morning		3					
Afternoon							
	25	26	27	28	29	30	1
Morning		4	3				
Afternoon							
	2	3	4	5	6	7	8
Morning		4					
Afternoon							
	9	10	11	12	13	14	15
Morning		4					
Afternoon			4				
	16	17	18	19	20	21	22
Morning		4					
Afternoon							

# License (1)

- THE WORK (AS DEFINED BELOW) IS PROVIDED UNDER THE TERMS OF THIS CREATIVE COMMONS PUBLIC LICENSE ("CCPL" OR "LICENSE"). THE WORK IS PROTECTED BY COPYRIGHT AND/OR OTHER APPLICABLE LAW. ANY USE OF THE WORK OTHER THAN AS AUTHORIZED UNDER THIS LICENSE OR COPYRIGHT LAW IS PROHIBITED.
- BY EXERCISING ANY RIGHTS TO THE WORK PROVIDED HERE, YOU ACCEPT AND AGREE TO BE BOUND BY THE TERMS OF THIS LICENSE. THE LICENSOR GRANTS YOU THE RIGHTS CONTAINED HERE IN CONSIDERATION OF YOUR ACCEPTANCE OF SUCH TERMS AND CONDITIONS.
- **1. Definitions**
  - **"Collective Work"** means a work, such as a periodical issue, anthology or encyclopedia, in which the Work in its entirety in unmodified form, along with a number of other contributions, constituting separate and independent works in themselves, are assembled into a collective whole. A work that constitutes a Collective Work will not be considered a Derivative Work (as defined below) for the purposes of this License.
  - **"Derivative Work"** means a work based upon the Work or upon the Work and other pre-existing works, such as a translation, musical arrangement, dramatization, fictionalization, motion picture version, sound recording, art reproduction, abridgment, condensation, or any other form in which the Work may be recast, transformed, or adapted, except that a work that constitutes a Collective Work will not be considered a Derivative Work for the purpose of this License. For the avoidance of doubt, where the Work is a musical composition or sound recording, the synchronization of the Work in timed-relation with a moving image ("synching") will be considered a Derivative Work for the purpose of this License.
  - **"Licensor"** means the individual or entity that offers the Work under the terms of this License.
  - **"Original Author"** means the individual or entity who created the Work.
  - **"Work"** means the copyrightable work of authorship offered under the terms of this License.
  - **"You"** means an individual or entity exercising rights under this License who has not previously violated the terms of this License with respect to the Work, or who has received express permission from the Licensor to exercise rights under this License despite a previous violation.
- **2. Fair Use Rights.** Nothing in this license is intended to reduce, limit, or restrict any rights arising from fair use, first sale or other limitations on the exclusive rights of the copyright owner under copyright law or other applicable laws.
- **3. License Grant.** Subject to the terms and conditions of this License, Licensor hereby grants You a worldwide, royalty-free, non-exclusive, perpetual (for the duration of the applicable copyright) license to exercise the rights in the Work as stated below:
  - a. to reproduce the Work, to incorporate the Work into one or more Collective Works, and to reproduce the Work as incorporated in the Collective Works;
  - b. to distribute copies or phonorecords of, display publicly, perform publicly, and perform publicly by means of a digital audio transmission the Work including as incorporated in Collective Works;

The above rights may be exercised in all media and formats whether now known or hereafter devised. The above rights include the right to make such modifications as are technically necessary to exercise the rights in other media and formats, but otherwise you have no rights to make Derivative Works. All rights not expressly granted by Licensor are hereby reserved, including but not limited to the rights set forth in Sections 4(d) and 4(e).



# License (2)

---

- **4. Restrictions.** The license granted in Section 3 above is expressly made subject to and limited by the following restrictions:
  - a. You may distribute, publicly display, publicly perform, or publicly digitally perform the Work only under the terms of this License, and You must include a copy of, or the Uniform Resource Identifier for, this License with every copy or phonorecord of the Work You distribute, publicly display, publicly perform, or publicly digitally perform. You may not offer or impose any terms on the Work that alter or restrict the terms of this License or the recipients' exercise of the rights granted hereunder. You may not sublicense the Work. You must keep intact all notices that refer to this License and to the disclaimer of warranties. You may not distribute, publicly display, publicly perform, or publicly digitally perform the Work with any technological measures that control access or use of the Work in a manner inconsistent with the terms of this License Agreement. The above applies to the Work as incorporated in a Collective Work, but this does not require the Collective Work apart from the Work itself to be made subject to the terms of this License. If You create a Collective Work, upon notice from any Licensor You must, to the extent practicable, remove from the Collective Work any credit as required by clause 4(c), as requested.
  - b. You may not exercise any of the rights granted to You in Section 3 above in any manner that is primarily intended for or directed toward commercial advantage or private monetary compensation. The exchange of the Work for other copyrighted works by means of digital file-sharing or otherwise shall not be considered to be intended for or directed toward commercial advantage or private monetary compensation, provided there is no payment of any monetary compensation in connection with the exchange of copyrighted works.
  - c. If you distribute, publicly display, publicly perform, or publicly digitally perform the Work, You must keep intact all copyright notices for the Work and provide, reasonable to the medium or means You are utilizing: (i) the name of the Original Author (or pseudonym, if applicable) if supplied, and/or (ii) if the Original Author and/or Licensor designate another party or parties (e.g. a sponsor institute, publishing entity, journal) for attribution in Licensor's copyright notice, terms of service or by other reasonable means, the name of such party or parties; the title of the Work if supplied; and to the extent reasonably practicable, the Uniform Resource Identifier, if any, that Licensor specifies to be associated with the Work, unless such URI does not refer to the copyright notice or licensing information for the Work. Such credit may be implemented in any reasonable manner; provided, however, that in the case of a Collective Work, at a minimum such credit will appear where any other comparable authorship credit appears and in a manner at least as prominent as such other comparable authorship credit.
  - d. For the avoidance of doubt, where the Work is a musical composition:
    - i. **Performance Royalties Under Blanket Licenses.** Licensor reserves the exclusive right to collect, whether individually or via a performance rights society (e.g. ASCAP, BMI, SESAC), royalties for the public performance or public digital performance (e.g. webcast) of the Work if that performance is primarily intended for or directed toward commercial advantage or private monetary compensation.
    - ii. **Mechanical Rights and Statutory Royalties.** Licensor reserves the exclusive right to collect, whether individually or via a music rights agency or designated agent (e.g. Harry Fox Agency), royalties for any phonorecord You create from the Work ("cover version") and distribute, subject to the compulsory license created by 17 USC Section 115 of the US Copyright Act (or the equivalent in other jurisdictions), if Your distribution of such cover version is primarily intended for or directed toward commercial advantage or private monetary compensation.
  - **Webcasting Rights and Statutory Royalties.** For the avoidance of doubt, where the Work is a sound recording, Licensor reserves the exclusive right to collect, whether individually or via a performance-rights society (e.g. SoundExchange), royalties for the public digital performance (e.g. webcast) of the Work, subject to the compulsory license created by 17 USC Section 114 of the US Copyright Act (or the equivalent in other jurisdictions), if Your public digital performance is primarily intended for or directed toward commercial advantage or private monetary compensation.

# License (3)

---

- **5. Representations, Warranties and Disclaimer**
- UNLESS OTHERWISE MUTUALLY AGREED BY THE PARTIES IN WRITING, LICENSOR OFFERS THE WORK AS-IS AND MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND CONCERNING THE WORK, EXPRESS, IMPLIED, STATUTORY OR OTHERWISE, INCLUDING, WITHOUT LIMITATION, WARRANTIES OF TITLE, MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, NON-INFRINGEMENT, OR THE ABSENCE OF LATENT OR OTHER DEFECTS, ACCURACY, OR THE PRESENCE OF ABSENCE OF ERRORS, WHETHER OR NOT DISCOVERABLE. SOME JURISDICTIONS DO NOT ALLOW THE EXCLUSION OF IMPLIED WARRANTIES, SO SUCH EXCLUSION MAY NOT APPLY TO YOU.
- **6. Limitation on Liability.** EXCEPT TO THE EXTENT REQUIRED BY APPLICABLE LAW, IN NO EVENT WILL LICENSOR BE LIABLE TO YOU ON ANY LEGAL THEORY FOR ANY SPECIAL, INCIDENTAL, CONSEQUENTIAL, PUNITIVE OR EXEMPLARY DAMAGES ARISING OUT OF THIS LICENSE OR THE USE OF THE WORK, EVEN IF LICENSOR HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.
- **7. Termination**
  - a. This License and the rights granted hereunder will terminate automatically upon any breach by You of the terms of this License. Individuals or entities who have received Collective Works from You under this License, however, will not have their licenses terminated provided such individuals or entities remain in full compliance with those licenses. Sections 1, 2, 5, 6, 7, and 8 will survive any termination of this License.
  - b. Subject to the above terms and conditions, the license granted here is perpetual (for the duration of the applicable copyright in the Work). Notwithstanding the above, Licensor reserves the right to release the Work under different license terms or to stop distributing the Work at any time; provided, however that any such election will not serve to withdraw this License (or any other license that has been, or is required to be, granted under the terms of this License), and this License will continue in full force and effect unless terminated as stated above.
- **8. Miscellaneous**
  - a. Each time You distribute or publicly digitally perform the Work or a Collective Work, the Licensor offers to the recipient a license to the Work on the same terms and conditions as the license granted to You under this License.
  - b. If any provision of this License is invalid or unenforceable under applicable law, it shall not affect the validity or enforceability of the remainder of the terms of this License, and without further action by the parties to this agreement, such provision shall be reformed to the minimum extent necessary to make such provision valid and enforceable.
  - c. No term or provision of this License shall be deemed waived and no breach consented to unless such waiver or consent shall be in writing and signed by the party to be charged with such waiver or consent.
  - d. This License constitutes the entire agreement between the parties with respect to the Work licensed here. There are no understandings, agreements or representations with respect to the Work not specified here. Licensor shall not be bound by any additional provisions that may appear in any communication from You. This License may not be modified without the mutual written agreement of the Licensor and You.